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Michigan Lake Superior Power Company
Hydroelectric Plant and Canal
Portage Street
Sault Ste. Marie
Chippewa County
Michigan

MI-1

HAER,
MICH,
17-SAUMA,
1-

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

Historic American Engineering Record
Heritage Conservation and Recreation Service
Department of the Interior
Washington, D.C. 20243

ADDENDUM TO
MICHIGAN LAKE SUPERIOR POWER COMPANY,
HYDROELECTRIC PLANT AND CANAL
Portage Street
Sault Ste. Marie
Chippewa County
Michigan

HAER No. MI-1

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HISTORIC AMERICAN ENGINEERING RECORD

MICHIGAN LAKE SUPERIOR POWER COMPANY: HYDROELECTRIC PLANT AND POWER CANAL

HAER MI-1

Location:	Sault Ste. Marie, Michigan. UTM: 16.704740.5152550 (Generating Plant) 16.702130.5152565 (Headgates) 16.701560.5152760 (Power Canal) Quad: Sault Ste. Marie South
Date of Construction:	1898-1902
Present Owner:	Edison Sault Electric Company
Present Use:	Hydroelectric generating plant
Significance:	Part of an industrial "empire" developed at Sault Ste. Marie (both in Ontario and in Michigan) by entrepreneur Francis Clergue. This low-head hydro plant was the longest in the world, and in design capacity (40,000 h. p.), was second only to Niagara in the U. S. The canal had the largest water-carrying section in the U. S., delivering 30,000 cubic feet per second.
Historians:	Terry Reynolds and Ronald Wilson, 1978.
Project Cosponsors and Cooperating Groups:	Michigan History Division; The City of Sault Ste. Marie; Edison Sault Electric Company; I.E.E.E.; Chippewa County Historical Society; Lake Superior State College.

"THE SOO HYDRO"
THE MICHIGAN LAKE SUPERIOR POWER COMPANY HYOROELECTRIC PLANT
SAULT STE MARIE, MICHIGAN, 1898-1902

VI. FEET OF CLAY: THE ERA OF PROBLEMS (1898-1913)

Emerging Problems
  Riparian Rights
  Leasing the Power
  Financing
Marketing Time
The Foundation Problem

VII. NEW BEGINNINGS: THE ERA OF EXPANSION (1913-1920)

Reorganization
Negotiating the Water Lease
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VII. EIPLOGUE: THE POWER HOUSE AND POWER CANAL AFTER 1920

CHAPTER I

FALSE STARTS
(EARLY CANAL COMPANIES)
(to 1894)

SITE DEVELOPMENT

GEOLOGICAL FORMATION

Some 10,000 years ago increasingly warm weather gradually drove back the glacial ice which buried the Upper Peninsula of Michigan and extended in an unbroken sheet northward. For thousands of years this ice had dominated the continent of North America, and from high points north of the Sault it had been relentlessly grinding its way southward to where the heat of the southern sun made a barrier beyond which it couldn't pass.

Long before the ice had ever come stealing southward, the rocks of the Lake Superior drainage area had been subjected to two billion years of more or less violent history. A great mountain chain extended across much of the area and tremendous volcanic activity poured out lava flows which now form prominent ridges in the Western Upper Peninsula and along the north shore of the lake. Later but still ancient seas deposited layer upon layer of sediments, and these form the flat lying rocks of the Eastern Upper Peninsula. The lowermost layer of these sedimentary beds is a thick sandstone which can be seen in Munising forming the Pictured Rocks and over which the Tahquamenon River flows at the falls. A resistant sill of this sandstone also forms the rapids at Sault Ste. Marie.

A sag in the rocks at the bottom of Lake Superior channeled the southward moving ice so that it gouged out a depression so deep that now, where the depth of the water in the lake is 1,300 feet, the bottom is 700 feet below sea level.

The ice also funnelled into long tongues down the basins of Lakes Michigan and Huron while in the north it became so thick that all the country surrounding Superior and Huron was buried and not even the highest hills pierced the icy vastness.

As the warmer climates moved north the southern tips of the tongues became lakes which gradually spread northward as the ice dams retreated. The weight of ice over the north country had been so great the crust of the earth was depressed several hundred feet, and much of the Great Lakes Basin was at or near sea level. As the ice melted, Lake Superior began to form the southwest tip near Duluth, which drained to the west and south, and later it spread eastward to Sault Ste. Marie. As the last of the great ice sheet melt in the increasingly warm summers a great body of water, now called Lake Algonquin, spread over all the Great Lakes.

This immense inland sea left elevated beaches and terraces in the highland areas of the Great Lakes country. The plains south of the Sault are the clay bottom of old Lake Algonquin but not much of the land around the Sault was high enough to reach above the ice waters of this huge lake.

When the ice had been peeled off sufficiently to relieve the tremendous weight, the crust began to rise and continues to do so. Gradually the Lake Superior Basin rose higher and higher and different outlets in the lower lakes resulted in the gradual lowering of the level of Lake Algonquin until Lake Superior emerged as a separate lake.[1]

Lake Superior was for a while connected to Lake Huron by a sluggish river whose shoreline can still be seen adjacent to the present river at the Sault (See 700 ft. elevation on Map #1, following page). When the remnants of glaciers finally disappeared the river receded until it reached a thick section of the underlying sandstone running at a right angle to the old river shoreline and formed a dam which prevented Lake Superior from lowering further. This sandstone ridge was covered by river bottom deposits of sand and boulders which formed many channels in the outlet across the whole valley. As the power of the main channel cut a wider and wider swath through the sand deposits of the older and slower river, many of the other channels dried up and left shallow depressions in the plain adjacent to the new main outlet.[2]

The river dropping approximately twenty feet over the sandstone ledge in one main channel, had reached a form which would remain virtually unchanged until man would alter it for his own use (See Map #1). One of the many alterations would be the adaptation of one of the old dried up river channels for a water power canal.

EARLY DEVELOPMENT

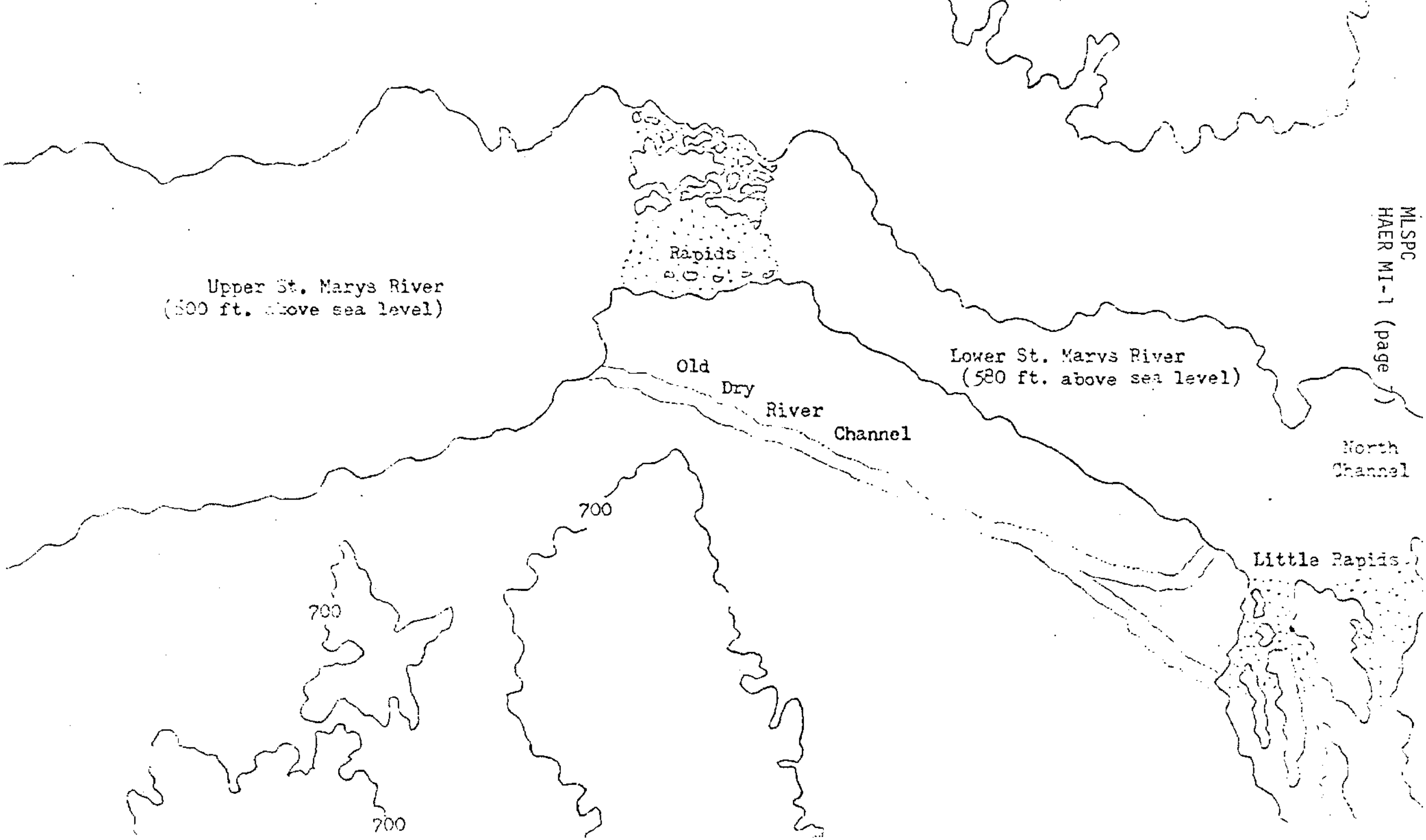
The site at Sault Ste. Marie owes its early development to its strategic location on a major waterway and to the rapids which form an obstruction in that waterway. From aboriginal times to the present the St. Marys River has been a major route for travel between the Lake Superior Basin and the lower lakes, and travelers on the river have always had to pause to ascend or descend the rapids.

Early French explorers found a large settlement of Chippewa Indians on the site. The first buildings of a permanent nature were erected here in 1668 when a small Catholic mission was founded by Father Marquette.[3] It is upon this first settlement that Sault Ste. Marie claims to be the oldest city west of the Allegheny Mountains with the possible exception of Santa Fe. While the French gave the area an historic legacy and its name, Sault Ste. Marie which means the falls of St. Mary, they accomplished little of a lasting nature in the way of physical change. The only remains of Marquette's mission and a French fort built in 1752, are the buried foundations of the old fort.

MAP # 1

Approximate appearance of the St. Marys Rapids prior to human alteration. 700 ft. topographical line shows shoreline of ancient river. Dry river channel became the proposed Whitney canal route.

Scale: 1 5/8 in. = 1 mile



The shortlived English dominance of the area (1755-1822) also accomplished little in developing the area except for the establishment of the headquarters of the Northwest Company which became the dominant fur trading company in the Lake Superior region. When the south side of the river was ceded to the United States after the Revolutionary War the company moved to the north side and made the first alterations and use of the river by building a small canoe lock and a sawmill.[4] The American side remained virtually unchanged until 1822 when the United States officially asserted their sovereignity over the region and established Fort Brady.

The village of Sault Ste. Marie, Michigan at that time consisted of fifteen to twenty buildings occupied by the descendants of the original French settlers, all of whom drew their living from the fur trade. The community grew slowly until the discovery of valuable mineral deposits in the western Upper Peninsula attracted pioneers to the Lake Superior region. As traffic increased on the St. Marys River so did the vitality of the town. The major occupation shifted from fur trading to the movement and accommodation of people and goods around the unnavigable waters of the rapids which was most easily accomplished on the American side.

In 1837, realizing the need for improved transportation, the new state of Michigan authorized the construction of a ship canal and lock at the Sault. From this decision emerged the first of many arguments over the control and use of the waters of the St. Marys River. In order to construct the ship canal the state contractor charged with preliminary excavations would have to cross a mill race which served a sawmill built by the soldiers at Fort Brady, and in doing so would destroy it. Upon being informed of the state's plan the Acting Quartermaster General of the Army ordered the commander of Fort Brady not to allow the destruction of the millrace. When the contractor decided to begin excavations at the disputed area his crew was driven off by soldiers armed with muskets and bayonets.[5]

This conflict between state and federal governments caused the ship canal plan to go before the U.S. Senate for approval. In 1840 a bill was put before the Senate which would donate 100,000 acres of land in Michigan to finance construction of the proposed lock. Kentucky's Senator, Henry Clay, opposed the bill contending the area was sparsely settled and the canal was "in reality a work beyond the remotest settlement in the United States, if not the moon."[6] Clay was not the only dissenter; local sentiment did not favor a canal because portaging ships and cargo was a profitable business.

The construction of a ship canal could not be delayed forever, however, for the area around Lake Superior was rapidly developing and water transportation was the cheapest, and in many cases the only way to move the bulk cargoes of wheat, ore, and lumber from the upper lake to the consumers of the East. Local companies tried to keep up with the increased traffic around the Rapids by constructing a horse powered railway and a plank road, but it was obvious this system was inefficient and would not be able to keep pace.

In 1852 a bill was finally passed by Congress which granted Michigan the right of way needed for lock construction and 750,000 acres of land to finance the project. In 1853 state commissioners contracted the canal and by June 18, 1855, it was finished.[7] The town experienced a small boom from the construction activity but this increase was temporary because less labor was needed to operate and maintain the locks than had been needed to portage the cargoes. In spite of the vast amount of traffic passing through the new lock and of the rapid development of the American Midwest, Sault Ste. Marie remained a small village which made its living on the river trade.

EARLY CANAL COMPANIES

THE SAULT STE. MARIE FALLS COMPANY AND THE WHITNEY CANAL

While the Sault Rapids had been considered an obstruction to transportation and progress in the early 1800's, entrepreneurs in the East had been building fortune by harnessing falling water. In fact the rapid industrialization of New England was in part due to the availability of rivers and streams which could be harnessed to turn machinery.[8] The importance of water power in industrialization was not lost on speculators, investors, and entrepreneurs. The residents of Sault Ste. Marie were not immune to this promise of wealth, and they were constantly reminded by the roar of the St. Marys Rapids that they too could build fortunes on the unused commodity at their doorstep.

In 1844 the first known attempt to harness the rapids was made by the Sault Ste. Marie Falls Company. The board of directors included Philetus A. Church, Samuel Ashmun, Peter B. Barbeau, Stephen R. Wood, and John P. Richardson. In their prospectus they stated:

> This company has secured four islands in the falls of the Riviere de Ste. Marie, which are desirable locations for the erection of stamping mills, furnaces and other manufactories, raw materials for which can be supplied in abundance from the mining districts now just being developed in the Lake Superior region of both the United States and Canada, including Bruce Mines. It is our humble opinion that at this point sufficient water power may be obtained for propelling a great deal of machinery.[9]

At approximately the same time, Samuel Whitney, formerly of New York but not a Sault businessman and local promoter, proposed the construction of a power canal to by-pass the rapids and purchased the claim to the old Methodist Mission property downriver, and the Bendrie claim, or an interest in it on the bay above the falls. There were the terminals to his proposed water power canal. They were approximately three miles apart and controlled both ends of a depression where the water had run around the falls in the past, making an island of the what is now the downtown area of the city. This was the route mapped out for the canal by nature, which had commendable advantages, principle among them, economy of construction[10] (see map #1).

Records make no further mention of the Sault Ste. Marie Falls Company or of the Whitney company so we must assume these companies went no further than purchasing land and promoting their enterprises. The plans of these two companies were prophetic, however, in that later power companies were constructed on the proposed sites of each company. On the islands which the Falls Company had purchased there was later erected the generating plants of the Edison Sault Light Company, the Chandler-Dunbar Water Power Company, a U.S. Government power house, and the U.S. Army Corps of Engineers power house which is there today. On part of the Whitney canal tract is the power canal which is the subject of this monograph.

The reasons for the failure of these early companies is not hard to imagine. It is doubtful that either interest had the capital to implement the construction of something as costly as what they proposed. In fact, later construction attempts showed that most companies always underestimated the money that would have to be invested to complete a large water power development. Also, Sault Ste. Marie was still a pioneer town with a population of only about 500 on the fringes of civilization, far from the market and labor supply. At the time of the conception of these power schemes the ship lock had not been construction, nor had the river been improved to allow large ships to make the passage to the Sault. The town was not quite "beyond the moon" as Henry Clay had implied, but it was far enough from civilization that it did not attract eager investors.

Between 1850 and 1870 there were no attempts to develop the water power potential of the St. Marys Rapids, but this period was one of development for the Lake Superior region. The building of the ship canal and lock in 1855 had made accessible the vast natural resources surrounding the lake. Iron ore and copper were carried by lake freighters. Grain from the western plains passed through the lock to feed the East. Lumber to build cities and pulp logs from the vast northern forests swelled the vessel traffic passing through the Sault. The 33,817 tons which passed through the Sault in 1856 had increased to 500,000 tons by 1870.[11] This increase in traffic necessitated the building of another ship lock in 1871.

Now that the waterway had been developed and markets had evolved in the rapidly growing cities of the Midwest, residents of the Sault began to question why raw materials could not be processed in the north and shipped south as finished products. Sawmills had been built to turn timber into lumber which gave the local economy a boost. Why couldn't the vast water power of the rapids be put to work grinding grain and pulp? Wouldn't it be cheaper to process raw materials in the Sault since the shipping costs for processed goods would be less? To local promoters it seemed only a matter of time before someone would recognize the potential of the Sault as an industrial site.

THE ST. MARYS FALLS WATER POWER COMPANY

THE LOCAL COMPANY

The increased economic activity in the Lake Superior region did revive interest in developing the Sault's water power potential. In the late 1870's, H.W. Seymour, active in Upper Peninsula lumbering operations, renewed interest in the old Whitney canal scheme and began to promote the idea to his business associates in Oetroit. James McMillan, Russel Alger, and the Oetroit real estate firm of George S. Frost & Company became active partners with Seymour, and the new company secured the old Whitney properties. Since their titles to the properties were defective, they at once began litigation and in the interim engaged a Detroit engineer, Colonel Duffield, to make surveys, plans and estimates for a water power canal on the route proposed by Whitney years before.[12]

As plans were being made, Seymour, a state senator, obtained passage through the Michigan legislature of Act 39, of the Public Acts of 1833, State of Michigan, authorizing the formation of a water power company and the diversion of water from the St. Marys River or Lake Superior subject to the consent of the Chippewa County board of supervisors.[13] With this act the company had the legal right to proceed with its plans, but this company also failed. The water power scheme was, however, only dormant, not dead.

Spurred by the city's 1885 proposal to build waterworks operated by water power, ten local citizens, including Seymour from the former company, again decided to undertake the building of the Whitney canal. Other members were William Chandler, Otto Fowle, Frank Perry, Louis P. Trempe, P.M. Church, George Kemp, Josh Greene, George Brown, and R.N. Adams. The company was organized under the act secured by Seymour as the St. Marys Falls Water Power Company. The company had an authorized capital stock of $1,000,000, consisting of 10,000 shares at $100 each. Each original stockholder held ten shares which meant the company began with $10,000 of stock actually subscribed.[14]

The property for the beginning and terminus of the canal had already been secured by the previous company but it still needed to obtain the property in between for the 50 foot wide canal it was planning. The company immediately began acquiring intermediate right of way and in a short period of time spent $40,000 and incurred and indebtedness of $20,000. Without even beginning construction the company had exhausted its supply of capital. These men, however, were determined to see the power canal succeed and began to seek outside sources of capital to complete the project. By early 1887 they had succeeded in attracting the interest of a group of LaCrosse, Wisconsin, businessmen who were impressed enough to begin negotiations to take over the properties of the local group.[15]

THE LACROSSE SYNDICATE

On May 25, 1887, the LaCrosse Syndicate, as it was called by local residents, completed the transfer of canal properties from the local company with the agreement on the part of the new controllers to spend %50,000 within twelve months from March, 1887, and an additional $50,000 eighteen months from that time in actual construction. Failing to do this, they were to return to the trustees of the old company a majority of the stock. The original ten stockholders had sold all their holdings at cost to the new investors and thus gave up control of the company but retained their 100 shares of subscribed stock in the enterprise.

The reorganized company at once began to buy additional rights of way so the canal could be 100 feet wide instead of just 50. It also bought large holdings of city and suburban real estate upon the presumption that it would rapidly increase in value once the canal was finished. This speculation in property was further spurred by the railroad, under construction, which would connect the Sault with Wisconsin, and by the construction of the International Railroad Bridge connecting the town with the Canadian Pacific Railroad across the river. These events precipitated a land boom which drove prices up and forced the LaCrosse Syndicate to pay higher prices than anticipated a year earlier. Besides land purchased for the canal, the company spent $250,000 on real estate, an immense sum for those days, especially since much of the land was undeveloped.[16]

As the land was being purchased the company hired a civil engineer, Colonel Edward Ruger of Iowa, who surveyed the route and drew plans for the canal.[17] His activities, the land boom, and the arrival of the railroads all combined to create an atmosphere of excitement and enthusiasm over the town's future. The residents sincerely believed the combination of geographical position on a major transportation route and the abundance of untapped water power would lead to the evolution of a city comparable to Chicago or Minneapolis. The optimism can be best expressed by excerpts from an article in the July 25, 1887 edition of the Detroit Evening News:

> What is by all as ambitious scheme as has been broached in Michigan for years is that which has just got in shape by the elections of the officers of the water power canal company. It is nothing less than to utilize Lake Superior as the greatest mill pond in the world, and to construct a mill race three miles long, lined with mills of whatever name of nature that may be established to take advantage of the facilities offered for cheap power and facile and economical freights . . . The position of the Soo for the utilization of the water power is simply unexcelled. Between the river above the falls of St. Mary and the river below there is a difference in level of eighteen feet, and the force which the vast body of water acquires by the fall can be studied best in the manner in which it comes tearing and roaring over the rocks, and churning itself into foam and spray in the rapids . . .
>
> There will be available for the purpose, of the canal a force of water equal to 40,000 horse-power. This in turn, is equal to the production of 100,000 barrels of flour per day, or any proportionate amount of work in other lines of industries. The entire power of Minneapolis, steam and water is equal to the grinding of but 25,000 barrels a day and even this cannot be counted upon as a permanent motive power for the reason that the streams which furnish the water power run low during the dry season, causing a cessation of operation . . .

> The cost of the proposed work will be between $400,000 and $500,000. The work will have to be done with steam shovels, and a vast army of laborers . . .
>
> The stock of the corporation is held by Cargill Bros., LaCrosse wheat men; Rosenbaum & Co., Chicago grain dealers; Robert Elliott and S.O. Fawcett, Milwaukee wheat operators; and Haight & Co., New York flour exporters. J.G. Stradley is the resident manager, William Chandler, treasurer; Joseph Clark, President; and Edward Ruger, the chief engineer . . . One of them says that while at Minneapolis $20 per horse power per year is charged, the local company can afford to sell at $10 per horse power and then make 50 per cent a year on the investment . . .
>
> The development of the power on this side has awakened great interest on the Canadian side, where the facilities are just as good as they are here, if not more so . . . There is equality as good reason for a little Minneapolis to grow up over there as there is for the establishment of a greater Minneapolis here.[18]

The expectations of the company were high but their engineer, Colonel Ruger, informed them that construction costs were going to be much higher than the $500,000 they had estimated. Nevertheless, preliminary work got underway with the clearing of land and further surveys. In March, 1888, a glowing prospectus was published, probably for the benefit of much needed future investors. In it were the following statements:

> It is the intention of the company to have the power completed by the fall of 1888 or the spring of 1889, so that power can be furnished to all who want to use it . . . The water power enterprise was never in better condition and prospects could not be brighter . . . A Block of stock was recently offered in Minneapolis, where it was quickly purchased by flour millers. The applications for power are surprising. One is for a mill that will produce 9,000 barrels of flour a day, another for a 750-barrel mill, one for a 3,000 barrel mill, one for a boiler works, and for numberless pulp and paper mills and other industries.[19]

This announcement was misleading, however, for the LaCrosse Syndicate had invested nearly half a million dollars, mostly in real estate, without making a major start on construction. Their capital began to run low and they were reluctant to risk any more of their fortunes on an enterprise which was starting to look like more than they could handle. Under the terms of the transfer from the previous owners and the franchise granted by the city, they had to invest $100,000 in actual construction by the fall of 1888 or forfeit their stock. They did not want to lose their investment but were unwilling to start the major work unless they thought enough money would be available to finish it. They made a compromise proposal under which they would put $100,000 into construction if the citizens of Sault Ste. Marie would subscribe a like amount for the same purpose.[20]

Local businessmen, loathe to see the venture fail and eager to reap the benefits of industrialization, agreed to try to raise the capital. In the final agreement between company and city, the company agreed to pay into three banks of the city $50,000 in cash on or before July 15, and approved securities for another $50,000 to be replaced by cash by October 15. The city had to arrange the sale of 2,000 shares of company stock at 50% of the par value of $100. In other words each party would have to invest $100,000. The money was to be used only for actual construction of the canal and expenses directly related to construction. Work was to be commenced within 30 days after payment of the first $100,000, and security given for the second $100,000. In addition to this $200,000 the company agreed to raise an additional $500,000, bringing the total to $700,000, which was estimated as the amount needed to construct the canal. The city also agreed to relieve the company of the cost of building and maintaining bridges across the canal and to lease 400 horse power at $15 per horse power per annum for a period of 20 years.[21]

Confidence in the enterprise was such that by August local citizens had subscribed the necessary $100,000 and, in October, passed a village ordinance granting the company the right to begin construction. The following is a brief outline of Village Ordinance No. XXX as amended by Ordinance No. XVIII:

Sec. 1: The city grants the company the right to excavate the canal, the canal must be not less than fifty feet in width, the company must not obstruct city streets.

Sec. 2: The city grants the right for raceways north from the canal to the river on company owned property.

Sec. 3: The company must take measures to safeguard people and property, the city is not liable for any negligence of the company.

Sec. 4: The city retains the right to cross the canal with any city works such as streets gas lines etc., the company must repair any city works damaged in construction of the canal at the company's cost, the city has the right for surface drainage into the canal but not sewerage.

Sec. 5: The company is granted the right to all lands set aside under the village resolution of December 13, 1875.

Sec. 6: The privilege of this ordinance is void unless agreed to within three months of its adoption.[22]

With this franchise from the city and the additional money put forward by its citizens, construction was finally ready to proceed.

DESIGN AND CONSTRUCTION

Few concise records exist to document the design and size of this first attempt at canal construction. The best representations of the canal design are a drawing of the canal scheme which still exists in the Edison Sault files (See HAER drawing, sheet 2 of 9, 1888 Canal Scheme), and a description from a newspaper of that time:

> The canal from the beginning of the intake to the first lateral canal at the lower end, as shown in the cut, will be 14,100 feet in length. The first 2,200 feet of the canal will be rock cut. The balance of the main canal and all the lateral canals and tail races will be earth excavations. The intake of the canal will be located about 800 feet out in the river. The canal will be 100 feet wide its entire length, and will carry a depth of water measuring fifteen feet throughout. The estimates anticipate a current of four miles an hour through the main canal, and with this current and the dimensions of the canal as above given, about 18,000 horse power will be obtained. This capacity can be easily increased, practically without limit. The speed of the current can be increased, and a small increase in the width of the canal will make a very large increase in the number of horsepower obtained. The Power Company has the right of way sufficient along the south side of the canal to admit of the construction of several railroad tracks the entire length of it.
>
> The plan for the mill sites could not better arranged. Each mill or factory will have a canal from which the water is taken in to give the power, and then passes into a tail race, and thence into the main tail race and out into the Hay Lake channel of the river. The manufactories situated on the outer strip of land, however, will receive their power from the canal and discharge the same direct into the channel.[23]

This plan followed the old Whitney scheme of a three mile long canal which was to empty through Mission Creek below a second set of rapids, known as the "Little Rapids," and take advantage of the additional three to four foot drop.[24] Taking into consideration the combined fall of the two rapids which varied between 22 and 25 feet depending on water levels, minus the slope of the canal, the available head was approximately 20 feet. Since the elevation of the terminus of the canal at that time was probably not more than ten feet above the water level of the river, the lower portion of the canal and the mill sites would have to have been diked and raised.

Each mill site was to be served by rail access and the sites were to be leased with the power as one unit. The arrangement of the mill sites on lateral canals was necessary since all power was direct drive and the mills had to be located on the exact spot the water fell. This was a method which had been used since early in the century and this design of the first Sault canal scheme was undoubtably influenced by earlier canal developments such as the Lowell Canal system in Massachusetts.

In July, 1888, the excavation work had been put up for bids and MacArthur Bros. of Chicago, a firm which later prepared the Chicago World's Fair site, was the successful bidder. The contract stipulated the work was to be completed in twelve months which the MacArthur Bros. said could be accomplished.[25] In August preliminary work began on the canal with men and teams of horses clearing the right of way and digging the basin of the canal. There was also a large excavating machine being tried out by its designer, a Mr. Watson, but it could not successfully dig through the dense red clay found in portions of the canal route.[26]

The original intent of the engineer, Colonel Ruger, had been to construct the canal with a slope of 1 in 2 on either side, expecting to avoid the expense of piling, but large cave-ins of the banks indicated that the canal walls would have to be supported. The company therefore decided to pile and crib the portion of the canal not bound by rocks, which was more than two thirds of the entire length.[27] Their plan was to put two tiers of piles, one along the bank and the other 18 feet back and tied to the first tier with timbers. The front tier which would form the sides of the canal, would be planked. It was also decided that certain portions of the bottom of the canal which ran through loose sand and muck would have to be piled and planked to prevent erosion.

By December 1888 the canal was beginning to take shape with partial excavation done the entire length of the canal with some sections nearing their final form. 250,000 cubic yards of earth and 6,000 cubic yards of rock were removed before the severe winter slowed operations.[28]

Before construction went back into full swing in the Spring of 1889 the decision was made to widen the canal. Applications for power and mill sites were being made faster than expected and the company was sufficiently encouraged to seed additional rights of way to enlarge the canal's capacity.[29] In addition to the flour mills planned by the LaCrosse Syndicate, negotiations were in progress for several large pulp mills and paper plants. In anticipation of widening the canal to 300 feet, the company held off on piling the south side of the canal.[30]

In April the weather warmed and construction began to pick up, with over 300 men working on different sections. Progress was somewhat hampered when fire destroyed the construction company's barn and most of the mules in it. Consequently men and teams were hired as fast as they applied for work with hopes of securing enough labor to bring the work force up to 700 men and complete the canal on schedule.[31]

By July the company had made the definite decision to widen the canal to 300 feet. The enlargement coupled with the decision to pile and plank the canal necessitated an extension of the time limit set by the original agreement to have the canal finished by May of 1890. A new ordinance was passed giving until May of 1891 to complete their work. The extra size and reinforcement also required a greater expenditure of money than originally planned. The LaCrosse Syndicate, which had already put their available capital into the enterprise and had solicited as much local investment as possible, began searching for new investment capital.[32]

When the decision was made to enlarge the canal, half of the $200,000 subscribed for construction had been expended, no new investors had been found, and people started to question the financial condition of the enterprise. When asked about rumors that the company was going to abandon the work, the company president Joseph Clark replied, "Absurd--all nonsense, not a word of truth in it. The thought of abandoning the enterprise has never entered our heads. You may say that I feel perfectly certain that we shall succeed in placing bonds and that the work will be practically finished by next July or August at the latest."[33] By September partial excavation had been accomplished along the entire route but the $200,000 was spent and still no new investors had been found. On September 10, 1889, work stopped and the MacArthur Bros. contract was cancelled.[34] Canal promoters were still optimistic about securing further financial backing, but it would be six years before new investors were found and nine years before construction was again undertaken. In the meantime, citizens hampered by the excavations which divided the city, and stockholders irritated by the unproductive stocks they held, clamored for some solution to the problem.

THE QUEST FOR NEW CAPITAL

When their contract was cancelled the MacArthur Bros. Company claimed an additional $62,000 was due them for unpaid construction costs. The canal company held that this demand was exorbiant and that the MacArthur Bros. Company was trying to regain money lost through mismanagement of the construction work. A lien was filed against the canal assets and both parties decided to take the issue to court. As this dispute dragged on it served to discourage prospective investors who were unwilling to get involved until it was settled. The available records are inconclusive but the evidence is that the dispute was eventually settled out of court for approximately $15,000.[35]

During this period representatives of the company traveled to almost every city in the Midwest and Northeast seeking new capital. By early 1890 they had succeeded in interesting a group of Chicago investors who were willing to complete the canal but who wanted to eliminate the city's interference in determining the size of the canal and other terms included in the city franchise. The city refused to back down on retaining its right to legislate on matters concerning the terms of the franchise and produced a stalemate. About this time a New York promoter, F.W. Brooks, who had been contacted by a company representative, appeared on the scene with the promise that he could get a large English syndicate to buy out the LaCrosse company and finish the project on a much larger scale than had yet been contemplated. The English offer was speculation but promised completion on a large scale. The Chicago offer was concrete but demanded the size of the canal be reduced to that of a 6,000-7,000 horse power canal. Canal backers divided into a large-canal and small-canal factions. Since the city council had assumed almost total control over canal matters because the LaCrosse Syndicate's franchise had lapsed, the controversy over which offer to pursue became a local political battle. The local Republicans interpreted the Chicago deal as a sure thing and the English deal as a "shot in the dark," and wanted to amend the franchise to suit the Chicago capitalists. The Democrats wanted the large canal and were opposed to the manipulation of the franchise. The future of the project would have a direct effect on the future of the city and the political arguments became heated.[36]

The Spring elections of 1891 were won by the Democrats who immediately asked F.W. Brooks to secure the investments he had promised he could obtain. Brooks sailed for England with two representatives of the English company, Captain and Colonel Hope, who had gathered data on the physical and financial condition of the project. Subsequent dispatches from England indicated that negotiations were favorably proceeding and closure of the deal was near.[37] Disruption occured, however, in the English money market due to the depression in Argentine bonds and the collapse of several large English financial firms, and the interested English investors backed out of the power canal negotiations. The Chicago financiers, snubbed by the local politicians, could not be coaxed into renewing their offer and the inert state of the project was unchanged from the Fall of 1889.[38]

Discouraged by the series of reverses, the canal stockholders tried to secure bonds to enable them to complete the project on a much smaller scale than what had been previously planned. The water power company stated that if the city would reinstate their franchise, they would make a herculean effort to issue bonds in the sum of $600,000 to liquidate debts and build a canal of 7,000 horse power.[39] On August 15, 1892, the city council passed a new ordinance which reinstated the city's right to control certain physical features of the canal without the use of condemnation proceedings. Local citizens and investors again became enthusiastic over the future of the canal even with the restrictive ordinances, but the United States was on the verge of a depression which would directly affect the search for new capital.[40]

In March of 1893, without warning, the Philidelphia & Reading Railroad went bankrupt. This disaster was followed by numerous other major business failures and before the year was out, 500 banks and nearly 16,000 businesses had declared bankruptcy. The English financial crisis which had caused the collapse of canal negotiations in 1890 was one cause of the American depression. As the English withdrew capital investments from the American market, they created a capital shortage which adversely affected the overexpanded American economy.[41] Trying to obtain money to complete the canal under these circumstances was not only hard, but nearly impossible.

In 1893 the St. Marys Falls Water Power Company, after spending over $400,000 in the purchase of rights of way and canal construction, defaulted in the payment of the interest on its bonds. In April, 1889, the company had given a trust mortgage on all of its property to three local banks which held the bonds as security for cash advances. The banks foreclosed on the mortgage on September 15, 1893, and ownership of the canal and all of the company assets passed to the bondholders.[42] The St. Marys Falls Water Power Company was finished and as the citizens of Sault Ste. Marie watched the banks of the partially finished canal erode under each succeeding rainfall, they gave up hope of its completion.[43]

CHAPTER I: Footnotes

1. Information on the geological formation of the Lake Superior Region taken from conversations with Ernest Kemp, Professor of Geology, Lake Superior State College, Sault Ste. Marie, MI

2. Otto Fowle, Sault Ste. Marie and Its Great Waterway (New York: G.P. Putnam's Sons, 1925) p. 16.

3. Stanley Newton, Story of Sault Ste. Marie and Chippewa County (Sault Ste. Marie: Sault News Printing Company, 1923) p. 58 Newton's book provided much general information on the history of Sault Ste. Marie which is not directly footnoted in the text.

4. Ibid, p. 8.

5. Issac DeYoung, "Beyond the Moon" A History of St. Marys Falls Canal and Environs. (A pamphlet published by the Sault Ste. Marie, Michigan, Chamber of Commerce, no date, available in the Bayliss Library, Sault Ste. Marie, Michigan) p. 7-8.

6. Ibid, p. 8.

7. Ibid, p. 8.

8. Norman A. Graebrer and Gilbert C. Fite, A History of the United States. (New York; McGraw-Hill Book Company, 1970) p. 545.

9. Sault Ste. Marie Democrat. May 26, 1887

10. Sault Ste. Marie News. May 10, 1891

11. Fowle, Great Waterway. pp. 437-438

12. Sault St. Marie News. May 10, 1891

13. Act #39, of the Public Acts of 1883, State of Michigan. (vf 32-17, Appendix I, Corporate Powers & Franchise Rights)

14. Sault Ste. Marie Daily News Record. October 24, 1902

15. Sault News, May 10, 1891

16. Sault Democrat. May 26, 1887

17. Ibid. June 23, 1887

18. Ibid. July 8, 1887

19. Sault News, March 28, 1888

20. Ibid. May 10, 1891

21. News Record. October 24, 1902

22. Sault Ste. Marie Village Ordinance No. XXX, October 22, 1888 (vf 32-17, Appendix VI)

23. Sault News. July, 1888

24. Sault Democrat. June 23, 1887

25. Ibid. July 19, 1888

26. Ibid. August 9, 1888

27. Ibid. December 13, 1888

28. Ibid. December 20, 19888

29. Ibid. December 13, 1888

30. Ibid. February 21, 1889

31. Ibid. April 25, 1889

32. Ibid. July 25, 1889

33. Sault News. July 20, 1889

34. Sault Democrat. September 12, 1889

35. Sault News. November 9, 1889

36. Ibid. January 24, 1891

37. Ibid. April 24, 1891

38. Ibid. May 10, 1891

39. Ibid. July 30, 1892

40. Ibid. August 16, 1892

41. John G Sperling, Great Depressions. (Chicago: Scott-Foresman and Company, 1966) pp. 100-103

42. "Discussion of the Situation at Sault Sante Marie, Michigan," (vf 1-130) p. 34

43. Evidence of this first canal construction can still be seen today on and west of the Sault Ste. Marie Municipal Golf Course. See HAER photos #2 and #3 of 120 for pictures taken in the 1890's of the abandoned portion of the canal right of way.

CHAPTER II

THE COMING OF CLERGUE (1894-1898)

NEW HOPE

It is interesting and perhaps essential to this history to note that a similar attempt to harness the St. Marys Rapids had taken place in Sault Ste. Marie, Ontario. The two attempts occurred at the same time; encountered the same physical and financial problems; and were eventually successfully completed by the same man.

In June of 1877, property adjacent to the rapids on the Canadian side had been obtained for a mill site by two men who, like Seymour on the American side, were apprently unable to secure the capital to undertake construction. In 1887 this property was purchased by the Sault Ste. Marie Water, Gas and Light Company which, upon obtaining water rights from the Ontario Legislative Assembly, became the Ontario Sault Ste. Marie Water, Light and Power Company. Construction on a power canal was begun in 1889 but lacking sufficient capital the company appealed to the town of Sault Ste. Marie, Ontario, for financial support in the form of stock purchases in the company. Like the Americans, the Canadians were hopeful of attracting industry by providing cheap water power, and the town responded by investing $228,000 in the water power company.[1]

With these additional funds the company was able to complete the development, but perhaps due to shortcuts taken in construction the canal walls gave way in the winter of 1894.[2] Since the city's investment in the project had been in the form of city bonds, the taxpayers were now stuck with a $263,000 debt and with a power canal which in its present shape was useless.

By 1894 both cities of Sault Ste. Marie had lost money on their canal developments and were unable to obtain the money necessary to put them into operating condition. The economic depression which affected both countries led them to give up hope of any solution to the problem in the near future.

It was at this time that the personal history of one man became inextricably extwined with the economic futures of both cities. This man was Francis Hector Clergue. In 1894, Clergue was on his way to look over a potential power site near Fort William, Ontario, for a group of Eastern financiers. While passing through Sault, Ontario, his attention was drawn to the half finished, and abandoned power canal near the river. He decided to stop and investigate and before leaving town, he had concluded an agreement with the city officials by which he acquired a conditional title to the power canal in return for assuming the town's debt from its power project. Clergue returned to the East and informed his backers he had found the perfect opportunity for an investment in water power. Clergue, described as having had an almost hypnotic power of persuasion, persuaded them to buy the Canadian canal for $225,000.[3]

Clergue returned to spend the winter in the Sault and began planning for the coming spring when warmer weather would allow construction to begin. In early February, 1895, Clergue, his consulting engineers Bollar and Boart, and the new company president, Douglas, visited Sault, Michigan, to inspect its partially finished canal. They made no offers at this time but seemed impressed with its possibilities.[4]

In May, Clergue proposed buying out the Michigan canal and the local banks which held the majority of the bonds made this public announcement:

> We wish to announce to the public that an option has been given the Lake Superior Power Company for the purchase of the water power right of way in this city. Said company agrees to purchase said property and develop the same to a very satisfactory extent, providing we can secure on reasonable terms the additional right of way sufficient to make said canal right of way 400 feet wide throughout, and secure the necessary city ordiances. They are under no obligations to take said property unless this right of way and these franchises can be secured. A reasonable price will be paid. An exorbiant price will ruin the project. It therefore rests with the people owning the right of way necessary to declare whether this great benefit to the city be secured or not. The loyal cooperation of every citizen is earnestly solicited.[5]

In the period of a few months a complete stranger had unexpectedly come to the Sault, looked over the two inert canals, agreed to undertake the building of both, and had lined up the capital in a period of depression when the efforts of many influential businessmen had failed. Clergue, however, was no ordinary businessman and was certianly no novice when it came to lining up capital for enterprises in which he took an interest.

THE EVOLUTION OF AN ENTREPRENEUR

As the man responsible for completing the Sault power canal in Michigan not to mention the building of an industrial empire in Sault, Ontario, Clergue certianly deserves a place in this study. Most of what we know about this amazing man comes from an unpublished biography written by Allen Sullivan, Clergue's personal secretary of many years, and Donald Eldon who wrote a chapter on Clergue for "Explorations in Entrepreneurial History," put out by the Harvard University Press. It would be beyond the scope of this paper to relate all of Clergue's experiences before he arrived in Sault Ste. Marie and it would, as Sullivan noted, "read too much like extracts from Dun and Bradstreet."[6] Some highlights of his career, however, are warranted.

Born and raised in Brewer, Maine, of a Puritan mother and a Hugenot father, F.H. (as he was called by many of his contemporaries) entered the world of business at the early age of nine delivering telegrams from the local railway station.[7] In school he was popular with both students and teachers, enjoyed excellent health, was somewhat of a dreamer, and was possessed by a limitless optimism; traits which would serve him well in later life.[8] After obtaining a law degree from the University of Maine he remained in Bangor and joined the law office of Laughton and Mason, where he had previously studied. Not satisfied to confine his activities to the practice of law, he began the entrepreneurial endeavors which motivated his business life. One of his first ventures was to sell Penobscot River ice to New York City when the Hudson River failed to freeze one year. Emerging with a substantial profit from this venture he started what has been called "an orgy of local developments" around Bangor.[9]

He started by obtaining local backing for and building a large electric light and power station using water power from the Penobscot River. This was followed by a new pumping station and an enlargement of Bangor's waterworks. Next came an electric street railway which had been purchased from a man in Richmond, Virginia, who had been unable to solve the technical problem of powering it up hills. Clergue moved it to Bangor where it became one of the first successful electric railways in the United States.[10]

Having temporarily exhausted the possibilities in Bangor, he planned, found backers for, and built a large resort complex at Green Mountain which included two hotels, a unique mountain railway, and a steamship line to and from the resort. This was followed by a pulp mill and banking firm, a company producing fog horns, and options on an iron mine in Nova Scotia.[11]

Clergue seemed to run from project to project and for good reason. Few of his ventures were profitable and many investors lost their money. Most of his projects continued in operation but had to be refinanced to survive. Others, such as the Green Mountain Resort, were simply dismantled. A few of his business partners, in one case the Eastern Trust and Banking Company, "saw the writing on the wall," and managed to save their company by freezing Clergue out from further involvement. This company subsequently prospered.[12]

His constant state of financial problems is exemplified by a letter written by Clergue's older and first partner, Fred Laughton, who had stuck with him through thick and thin, mostly thin. This letter was addressed to the Thompson Houston Company which had supplied equipment for the Bangor Electric Street Railway.

October 28, 1891

"Ha, Ha, Ha, Ha, Ha, Ha, Ha, Ha, Ha, Ha, Ha, Ha, Ha, Ha, Ha, Ha, Ha, Ha,
Ha, Ha, Ha, Ha, Ha, Ha,
Ah----------Ha, Ha, Ha, Ha, Ha, Ha, Ha, Ha, Ha, Ha, Ha, Ha, Ha, Ha, Ha,
Oh Lord!

Yours truly,
F.M. Laughton

P.S. Fearing that the above may lack clearness I hasten to add, that this mirth is provoked by your saying you have some notes unsecured, and asking if I can send some collateral.

Your mammoth Company and its giant head hold as security for past and future advances, my lands, my tenaments, my hereditaments, my prospects, my aspirations, my

"Hopes and fears, and prayers and tears, my limbs, my wind, my muscle, with a covenant to hustle, to secure by ceaseless bustle, things to mort-gage with the rest.

My partner has likewise with cheerfulness and alacrity turned his gizzard inside out, and his crop is in your keeping. You have the entire issue of bonds, of the Public Works Company, including the Milford and Bradley series, which should be surrendered.

You know the law requires certain things to be worn when one finds it necessary to frequent the haunts of men, so I do not send you my clothes. I have a spare pair of suspenders, not badly worn, which I would forward, excepting that I am not in a position to prepay the freight, and I like to do things properly or not at all. I enclose an unpaid bill for my horse's board which you may hold, not subject to redemption, as I shall have a duplicate within a few days.

Yours truly,
F.M. Laughton [13]

We can be reasonably sure that most of Clergue's business partners did not share Laughton's sense of humor since from this point on Clergue was unable to persuade any more local capitalists to invest in his ideas.

Reviewing Clergue's activities it is hard to recall that he was educated in law and not in engineering. His endeavors were not failures in terms of function but of profit. He seemed willing to tackle any problem no matter how technical. Sullivan, in commenting on Clergue's interest in engineering projects, said that "He was not a qualified engineer, though he could discourse at length on engineering possibilities; thus he had, in a sense, the courage of ignorance, a strange term to apply to one of his calibre, but this very ignorance nerved him to attempt that which a purely technical man would have hesitated, while his persuasive qualities drew others to follow his ventures."[14]

Far from being a total loss, Clergue's ventures in Maine had given him valuable experience in banking, railroads, water power development, electrical engineering, pulp making processes, and transportation. His experiences had also brought him into contact with many financiers and politicians. These experiences and acquaintances were open to many more doors for him than his failures had closed. Expanding his sphere of promotion, Clergue went to England where he engaged capital in a great undertaking at Mobile, Alabama, which included dry docks, shipyards, and a bank. This venture completely failed, as did his American Trust & Banking Company with offices on Wall Street.[15]

One of Clergue's most interesting ventures started when the Shah of Persia sent a delegation to Washington to appeal to the United States Government to solicit aid in constructing railways in his country. Washington was not interested but the Secretary of State, James G. Blaine, was. Blaine, who was a native of Maine, and Harold Sewall, a Main shipbuilder, contacted Clergue and asked him to travel to Persia to secure from the Shah a private franchise for railways in Persia. Together they put up $25,000 for Clergue's traveling and negotiating expenses and Clergue was on his way to Teheran.

Traveling by caravan on the last leg of his voyage Clergue noticed pools of oil seeping through the desert floor and decided that there were more possibilities in Persia than just railroads. In the subsequent months of negotiations Clergue gained the good graces of the Shah and emerged with a tentative agreement giving Clergue and his backers an exclusive petroleum monopoly throughout Persia for 25 years, a water supply monopoly for the cities of Persia for 25 years, all railway franchises, telephone, indigo and sugar monopolies, for 100 years, and a banking concession for the whole country.[16]

In view of the present wealth of Persia (now Iran) the successful conclusion of this agreement would have been Clergue's crowning achievement in life. But upon returning to the U.S. he was unable to find sufficient investors willing to risk their capital in so distant and backward a country. Political maneuvering by Russian politicians also undermined the terms of the agreement which he had reached with the Shah, shattering hopes of his Persian venture. Calling on that unlimited optimism he was characterized with, Clergue again crossed the ocean, this time to Bulgaria whose railways he refinancied with English capital. For these services he obtained a healthy commission and revived his badly depleted financial reserves.[17]

Returning to Maine Clergue organized numerous mining companies which failed to prosper and proposed a scheme for huge dams and power plants on the Penobscot River. This last project would have required millions of dollars, however, and Maine's investors were too wary of Clergue by this time to give it serious consideration.[18]

Clergue seemed to have reached the end of his opportunities, but he looked upon the failure to gain support in Maine as a mandate to look for new geographical areas for investment and new capitalists who had not been affected by his reputation. In 1894, at age thirty-eight and armed with a fund of practicable knowledge gained from earlier experiences, Clergue traveled west looking for new fields to conquer.[19]

THE OPENING OF ALGOMA

Stopping in Sault Ste. Marie Clergue was drawn to the rapids by the incessant roar of the falling water and on the way observed the defective canal which the Canadian company had tried to construct. Realizing the possibilities of the location he enquired where he might find the town solicitor to obtain more information.[20] Finding out the financial condition of the canal company and of the town's debt, he decided that there was no reason to travel further in search of an opportunity for water power development. Here was the entire outflow of Lake Superior virtually untapped, a water power canal which only needed enlargement and improvement, secured water and property rights, and a town eager to eradicate its debt and rise industrial expansion.

The Algoma region, as the area north of the Sault is called, was untouched but held the promise of vast wood and mineral resources ready to feed industries which could use power created at this site. Bulk shipping by water, the cheapest transportation available, was well established and rail links to the east, west and south had just been completed. Here was an opportunity Clergue couldn't resist. It was as though fate had called on him to weld all these resources into an industrial empire.

Clergue wasted no time in calling a town meeting to put his ideas before the people. Once gathered he told the citizens of his visions and offered to assume their debt in return for their canal and their cooperation. From his manner, bearing and confidence the citizens could tell that here was a man who could solve their problems. The meeting ended in a unanimous acceptance of all he proposed. F.H. Clergue and the two cities of Sault Ste. Marie were launched on the largest undertakings of their lives.[21]

From his attempts to line up capital for the Persia company and the hydro development on the Penobscot River, Clergue had learned that too large an undertaking might frighten away capitalists rather than attract them, so when trying to sell his idea to his Philidelphia backers he only proposed the modest plan of obtaining and developing the Candian canal into one which would produce 20,000 horse power. This plan was easily sold and Clergue was back in the Sault before winter as vice president and general manager of the newly formed Lake Superior Power Company.

Clergue spent that first winter in Bishophurst, an old stone house belonging to the local Catholic diocese. Here he learned about life in the north and of the severity of its winters. Besides the normal pork and mutton, he dined on venison and partridge, and on whitefish speared through the ice on the river, meals which had to be quickly eaten before they froze on his plate. Bishophurst was poorly heated. Here a pan of water not near a stove or fireplace froze solid, and the simple act of getting dressed was an affliction. It was no wonder that the Bishop spent his winters elsewhere and made this house available to whoever was willing to live there.[22]

Having learned his lesson, Clergue made other arrangements for living quarters before the next winter rolled around. Standing on the property purchased with the power canal were the remains of the old Northwest Company outpost which had been abanoned since its razing by the Americans in the War of 1812. One building, however, remained in fair condition; the stone power magazine. Clergue added an overhanging log second story so it resembled a frontier blockhouse. It was such a authentic job that even the locals in time claimed it was the old original Hudson's Bay Company blockhouse.[23]

This new home served him well for it was adequately heated and close to his work. It also provided him with a unique place to entertain guests, and in later years the "blockhouse" became noted for the catered dinners and parties held there.[24] To add to the structure's appeal Clergue even added a pet bear which was chained in front (See HAER photo #2 of 120).

That first winter Clergue was too busy to spend much time shivering at Bishophurst. It was clear that Clergue was not going to be satisfied with just developing the Candian canal as evidenced by his inspection of the American canal in February. It was also clear that plans would have to be made for the use of power produced. Having advertised the power which would be created by the reconstruction of the Candian canal, he found that few companies were ready to establish new industries in the northern frontier.

Apparently if industry was to locate here to take advantage of the power Clergue produced, then he would have to create it. As he said in a later speech to the Toronto Board of Trade:

> In our simplicity at that time it seemed to us that we simply had to go on, construct the dam, establish the water wheels in place, and that all the manufacturers in the world would come there to seek for power. We made the first investment, and began the work, but we were disappointed in our applications for power, and before our construction was entirely completed we had decided that we should have to go still further than the original and initial development of the water power, into its actual utilization.[26]

The lack of applications was not really a disappointment, it was excuse for expanding the scope of his operations. In fact it became a pattern for Clergue in Algoma to constantly expand company operations rather than encourage outside companies to take part in the development of the region.

In surveying the best possibilities for power usage, Clergue noted the vast quantities of pulpwood which covered the Algoma District and the rapid growth of shipping on Lake Superior. Returning to Philadelphia he convinced the financiers of the company and others to take advantage of the opportunities at Sault Ste. Marie, Ontario, and expand their operations there. By May of 1895 he had succeeded in the formation of a corporate structure which included the Sault Ste. Marie Paper and Pulp Company with a capitalization of $2,000,000, and the Algoma Dry Dock Company with a capitalization of $1,000,000. These were in addition to the Lake Superior Power Company with a capital stock of $2,000,000, and the Togona Water and Light Company with capital of $200,000. The investors Clergue had brought into the enterprise were 25 prominent Eastern businessmen, the most notable of which were "Messrs. Cramp of the Philadelphia ship building firm, Mr. Berwind of the Berwind-White Coal Manufacturing Company, Mr. S.R. Shipley, President of the Provident Loan & Trust Company of Philadelphia; and the Messrs. Hyde and Sewell, great ship builders of Bath, Maine.[27]

With the exception of Sewell's part in the Persia venture, none of these businessmen had been involved in any of Clergue's previous schemes. Still it was a notable achievement for anyone to line up that much capital in those days, but Clergue became known for his ability to attract capital. A later investor, John Terry of the ultra-conservative New York firm of Sloan-Taylor-Terry-Sage, related that although he had listened to and turned down schemes as visionary as Clergue's he was "so convinced by the force of this man's magnetism that he immediately became enthusiastic and invested in the enterprise."[28]

In a little less than nine months Clergue had gone from the discovery of a sleepy northern Canadian town with a defective canal to a conglomerate capitalized at over five million dollars. He now contemplated the completion of the mammoth American power canal which had already exhaused the resources of the previous company.

CANAL NEGOTIATIONS

Clergue's offer to buy out the American canal revived the almost forgotten idea of Sault Ste. Marie, Michigan, becoming a great manufacturing city, and great pressure was put on property owners and city officials to make it as easy as possible for the Lake Superior Power Company to secure the rights to the canal, especially since the company proposed to develop it to the previously undreamed of width of 400 feet. Some of the pressure was removed when Clergue said that if the 400 foot right-of-way could not be obtained, he would develop the canal as large as possible on the 150 foot right-of-way already secured; but local businessmen still pushed for the largest size possible. This plea was printed in an August 1895 newspaper:

> A 150 foot canal, of course, would mean a nominal development that would only supply power sufficient to run the one big paper and pulp mill that they (the LSPC) intend building. The other enterprises under contemplation, and which would certainly be realities if the water power were developed to the extent desired, would have to be dropped. What the Soo wants now is the fullest development of the big project, one that will bring many business enterprises here. The city, however, may have to be satisfied with half loaf, unless the condition materially changes from what it is at present . . .
>
> The committee in charge of securing the options has worked faithfully . . . but has exhausted every proposition to induce the owners of certain lands required to accept a reasonable price for their holdings . . .
>
> The future prosperity and growth of the city hangs tremblingly in the balance, which can quite easily be turned in the right direction if the proper spirit is envinced by those in whose hands the affair lies.[29]

The delay caused by property negotiations was particularly irritating to canal supporters, for Clergue was exhibiting his serious intentions by rapidly finishing the Canandian canal and laying plans for two large pulp mills to make use of the power produced there. In spite of the failure to secure a complete right of way for a 400 foot canal, the Lake Superior Power Company (which for the sake of brevity will be refered to as the LSPC) decided to go ahead and secure the right of way bonds which were available and to develop the canal upon the basis of whatever additional property could be obtained. In May, 1895 the company paid $10,000 to secure the option on the canal and on August 14 Edward V. Douglas, the company president, and Clergue paid in the balance of $58,370,062 to complete the transfer of deeds.[30] The deed conveying the title carried with it a contract agreement to begin construction work within three months and to complete within three years a canal that would be at least 15 feet deep and 60 feet wide through the rock cut.

The rights secured included the old right of way three miles in length, varying from 150 feet to 400 feet in width, and 100 acres for mill sites fronting on the St. Marys River at the Little Rapids. Considering the acquisition of right of way and construction costs of the St. Marys Falls Water Power Company came to nearly $400,000, the $58,370.62 paid by the LSPC was quite a bargain. This figure represented the amount owed the bond-holders who had foreclosed on the mortgage of the St. Marys Falls Water Power Company. While most people were glad to see the canal taken over by the LSPC, the local citizens who had lost money in the first company probably resented Clergue's obtaining the canal cheaply at their expense.

Even though the LSPC still had the option to back out of the deal if certain conditions were not fulfilled by the city and the property owners, the completion of some sort of power canal now seemed assured. The company appeared to have unlimited sources of capital and even if the extensive operations on the other side of the river were drawing on this money, it seemed to local citizens that LSPC would be able to complete the long awaited canal.[31] In November Clergue announced that work would commence in the spring of 1896 on the power canal and "the biggest pulp mill in the world."[32] This was pure speculation, but in view of the rapid development of works on the Canadian side, local optimists were greatly encouraged.

Despite speculation on future industries projected for the community, no plants could be built until the canal was finished, and in the Spring of 1896 no new construction had yet been undertaken. Negotiations for the property necessary to construct a 400 foot wide canal had reached a deadlock and in July 1896, Clergue announced that since the property owners involved would not sell for a reasonable price, the width of the canal would be reduced to 250 feet but would be made deeper to obtain the same flow of water. Work was also being delayed because the terms of the franchise to be granted the LSPC by the city had not been resolved.

City ordinances governing the canal had been a subject of controversy in the past. The city council in previous negotiations had retarded the settlement by insisting they should have final say on canal construction since it would effect the physical features and functioning of the city. The city fathers were worried about such factors as right of sewerage into the canal, right of way across the canal, terms of taxation, and renewal of property damaged in construction. By 1896, however, the residents were in no mood to argue. Bowing to the will of the people, the city council unanimously passed the ordinances granting a franchise on terms desired by the LSPC.[33] The ordinance carried with it a stipulation, however, that it would be null and void unless construction began within six months and the canal completed within three years.[34] This gave the company until July 21, 1898 to finish the project.

With the major problems of property right of ways and the city franchise settled, people again began to dwell on the important changes the canal would have on the Sault. According to the plans of the power company, the canal might be only 150 feet wide and 15 feet deep, but it would probably be 250 feet wide and 20 feet deep. If the latter plan was followed, the canal would develop at least 40,000 horse power. This was twice the power of the Canadian Sault's canal and larger than any water power development in the world with the exception of the Niagara project. The Sault again looked forward to becoming a major industrial city.

In August 1896, work began on an experimental carbide plant with the cooperation of the LSPC. This plant would determine if carbide could be produced profitably. This seemed to indicate that work on the canal would soon begin. Power for this experimental plant, however, was supplied by cable from the Canadian power generating station and construction on the canal still had not commenced. Sensing the impatience of local residents, Clergue issued a statement in November of 1896, concerning preparations being made by the Lake Superior Power Company:

> At a meeting of the board of directors of the Lake Superior Power Company today it was decided to increase the width of the canal from the minimum size of 250 feet as originally contemplated, to somewhere near the maximum of 400 feet. The exact size I do not wish to state at present. This change in size of the canal will necessitate a complete lateration of the plans and a consequent delay with letting of contracts and commencement of work.
>
> We must have every detail of the work carefully planned before we can let contracts. It is a task of great magnitude to prepare the plans for an undertaking of such vastness as we propose . . . As soon as possible after the plans are finished, we will let contracts and begin active work.
>
> I know the people of the American Soo are anxious and even impatient to see us commence operations. They are not any more anxious for the completion of the project than our company. It is a herculean task to prepare plans and make other necessary arrangements for an undertaking of such gigantic proportions. Therefore, in order to have everything just right, we must make haste slowly . . . We are pursuing a careful, conservative course in this undertaking, which will call for the outlay of a vast sum of money . . . As we are anxious to realize on the investment, active work of construction when commenced will be rushed to completion as fast as possible.[35]

The changing canal plans (See Chapter III) required new property, additional engineering studies which delayed construction, and new sources of capital. In October of 1897 work had yet to begin and people began to doubt the good intentions of the power company. During the planning stage the company could do nothing but reassure the town no construction could commence until canal and power house designs were complete.

THE MICHIGAN LAKE SUPERIOR COMPANY

Up until June 28, 1898, the canal planning and preliminary work proceeded under the auspices of the Lake Superior Power Company. In early 1898 it was decided to form an American company to undertake the actual construction, since plans for the development were taking form. The decision to establish an American company was probably made because the Lake Superior Company was organized in Ontario and thus might be considered a "foreign" company, even though it was American owned. As a "foreign" company it could have trouble obtaining state and federal permits to operate. In fact, in order to operate under Act #39 which authorized the diversion of water from the St. Marys River, the company undertaking construction and operation of the canal had to be incorporated in Michigan.[36] Future operations could also be hampered by prejudice if the company was perceived as representing alien interests. In addition, by forming a subsidiary company, the "parent" Lake Superior Power Company would be protected against financial liability if the canal development was a financial failure.

In March 1898, the LSPC transferred its American properties to Edward V. Douglas who acted as Trustee, and in August of that year the St. Marys Falls Power Company right of way was also transferred in trust. On June 28th the Michigan Lake Superior Power Company was incorporated in Michigan with a capital of $500,000. (For the sake of brevity the company will be hereafter referred to as the MLSPC) By May 29th, 1899, the transfer of property and canal rights of way were completed from Douglas to the MLSPC. The LSPC received in exchange $495,000 of the capital stock of the Michigan Company and $5,000 in cash.[36] The stockholders and directors of MLSPC were listed as Edward V. Douglas, President; Walter P. Douglas, Treasurer; Francis H. Clergue, Vice-President and General Manager; Lynde Harrison, and F.S. Lewis.[38]

On September 13, 1898, an issue of $3,500,000 of 5%, 50 year first mortgage gold bonds was authorized by the directors of the MLSPC. In return for the transfer to the MLSPC of the contract for power with the Union Carbide Company which had been signed with the LSPC on April 2, 1898 $650,000 of the receipts were to be paid to the LSPC. $2,100,000 of the proceeds were slated for construction costs, and $450,000 constituted the underwriters' commission, with the balance of $300,000 reserved for contingencies and interest during construction.[39] The authorized bonds were sold without problems on the Philidelphia stock exchange.

Apparently the Philadelphia syndicate which Clergue represented was using the formation of the MLSPC to obtain working capital for the LSPC and to make an early profit at the expense of the financial integrity of the new company. Negotiations costs for the Carbide contract must have been minimal, but the LSPC obtained over half a million dollars in cash for the contract rights. The commission of $450,000 for the sale of the bonds was a rather large percentage of the entire issue, but the fact that this commission went to the Provident Loan & Trust Company, a major stockholder of the LSPC, seems to explain this figure.

The formation of the MLSPC and the issue of bonds was shrewd dealing on the part of Clergue and the Philadelphia syndicate which controlled the allied companies. They had retained complete control of the MLSPC, held its stock, and made $1,100,000 in the process. If for some reason the company failed they would lose nothing since the bondholders were now the only investors with actual cash in the MLSPC. On the other hand, if the Michigan company was successful the syndicate could pay off the bonds and retain the profits and the company.

By this time the company engineers had finished their design for the canal and powerhouse, and with money in hand, the MLSPC was ready to begin construction. The city franchise stipulated that the canal had to be finished by July 21, 1898; obviously this was impossible. Therefore, a new ordinance had to be negotiated. On October 4, 1898, the city and company agreed on a new ordinance containing the following provisions:

Section 1: The company was given the right to improve the water course in the city commonly known as the water power canal.

Section 2: The company is given the right to construct a railroad adjacent to the south side of the water course across city right of ways.

Section 3: The must undertake improvements without unnecessary inconvenience to the public.

Section 4: The company shall maintain the existing temporary bridges at Meridian, Ashmun, Seymour, and Bernier Streets, construct new temporary bridges at Maple Street and Hay Lake Road, construct new temporary foot bridges at Bingham Ave. and Fort Street.

Section 5: The company shall maintain sanitary conditions in the construction area and maintain all existing water and sewer lines crossing the water course.

Section 6: The city retains the right to construct new streets, water, sewer, gas lines, etc., across the water course.

Section 7: The city shall assume no liability for any injury caused by the negligence of the company.

Section 8: The company shall construct a canal producing at least 40,000 hydraulic horse power. The company shall provide sewer outlets on the south side of the water course or a trunk sewer with an outlet on the river.

Section 9: The city within ninety days of notice given by the grantee will remove all bridges excepting those at Maple street and Hay Lake Road, all bridges thereafter constructed by the city shall be on span not exceeding 260 feet with a clearance of five feet above the level of Lake Superior. The city will make special arrangements for taxation beneficial to the company.

Section 10: The company shall construct suitable bridge abutments for permanent bridges to be constructed by the city. If the grantee fails to fully complete and operate the water course within three years all public conveyance across the water course shall be replaced in as good a condition as they are now.

Section 11: All streets and alleys shall be kept free from obstruction.

Section 12: The railroad established by the company shall service all businesses along its route at a reasonable rate, the railroad shall be built to conform to all streets and alleys it crosses now and in the future.

Section 13: At any time the city shall be of a population of 100,000, the company shall raise or lower its railroad to pass over or under the city streets as to facilitate travel.

Section 14: This ordinance shall be perpetual unless transferred to other than the owners of said lands.

Section 15: This ordinance shall continue to pertain to new owners.

Section 16: The company shall file acceptance of this ordinance within thirty days to be valid. If all provisions of this ordinance are not kept or performed it shall be considered void and all rights and priveleges shall revert to the city.[40]

With the city ordinance out of the way one last legal matter had to be settled. Under the provisions of Act #39, the Chippewa County Board of Supervisors had to give permission for water to be diverted into the canal, and the company wanted to be sure they had this sanction before work was begun. The Board gave its permission on October 10, 1898, and construction of the long awaited canal began.[41]

CHAPTER II: Footnotes

1. "History of the Great Lakes Power Company," (A short typewritten history; no author noted; obtained from the Great Lakes Power Company, Sault Ste. Marie, Ontario. Now available in Lake Superior State College Library)

2. Margaret Van Every, Francis Hector Clergue and the Rise of Sault Ste. Marie as an Industrial Centre. (Paper available in vertical file of the Sault Ste. Marie, Ontario, Public Library)

3. Donald Eldon, Explorations in Entrepreneurial History - Francis H. Clergue, (Cambridge, Mass.: Harvard University Press, 1935) pp 257-8

4. Sault Ste. Marie News, February 9, 1895

5. Ibid. May 18, 1895

6. Allan Sullivan, Francis H. Clergue (An unpublished biography now available in the Lake Superior State College Library) p. 34

7. Ibid. p. 22

8. Eldon, Explorations. p. 254

9. Sullivan, Clergue. p. 25

10. Ibid. p. 26

11. Ibid. p. 35

12. Eldon, Explorations. p. 255

13. Sullivan, Clergue. p. 35-6

14. Ibid. p. 34

15. Eldon, Explorations. p. 256

16. Sullivan, Clergue. p. 41

17. Ibid. pp. 46-7

18. Eldon, Explorations. p. 256

19. Ibid. p. 257

20. Sullivan, Clergue. p. 1

21. Ibid. p. 5

22. Ibid. p. 6

23. Fowle, Great Waterway. pp. 324-5

24. Ibid. pp. 238-239

25. Sullivan, Clergue. p. 56

26. "An Instance of Industrial Evolution in Northern Ontario, Dominion of Canada," an address by Francis H. Clergue to the Board of Trade of the City of Toronto, April 2nd, 1900. (Sault Ste. Marie Public Library, Ontario, R 338.4)

27. Sault News. August 17, 1895

28. Eldon, Explorations. pp. 258-259

29. Sault News. August 10, 1895

30. History of the Consolidated Lake Superior Company. A typewritten history obtained from the Public Relations office of the Algoma Steel Corporation. Only the main body of the paper remained with no reference to author. Footnotes and bibliography unavailable. A copy is now available in the Lake Superior State College Library, Sault Ste. Marie, MI.

31. Sault News. August 17, 1895

32. Ibid. p. November 30, 1896

33. Ibid. November 28, 1896

34. "Sault Ste. Marie City Ordinance No. LVII." (City Clerk's Office, Sault Ste. Marie, MI)

35. Sault News. November 28, 1895

36. Act #39 (vf 32-17)

38. "Articles of Incorporation of the Michigan Lake Superior Power Company." (vf 32-17, Corporate Powers and Franchise Rights, Appendix IX)

39. History of Consolidated. p. 20

40. "Sault Ste. Marie City Ordinance No. LXXXII." (vf 32-17, Corporate Powers and Franchise Rights, Appendix X.)

41. "Copy of Resolution of Board of Supervisors Granting Permission to the Michigan Lake Superior Power Company to Oivert Water into Canal or Canals." (vf 32-17, Corporate Powers and Franchise Rights, Appendix XII)

CHAPTER III

INITIAL PLANS AND SURVEYS
(1896-1898)

On Monday, August 4, 1896, J.W. Rickey of the Lake Superior Power Company of Sault Ste. Marie, Ontario, was transferred to the American side of the St. Mary's. He began work immediately with Hans von Schon, who Clergue had just appointed chief engineer of the projected development, abstracting descriptions of the properties which had been acquired through the purchase of the assets of the St. Mary's Falls Water Power Company.[1] Von Schon and Rickey, together with M.H. Barnes, another Lake Superior Power employee, carried most of the early design load.

Rickey, an 1894 graduate of Rensselaer, worked on the project for about a year. He participated in several early design projects including the design and location of the intake and canal prisms, methods of pit wall construction, penstock units, and power house roof trusses. In 1897 he left the Clergue organization to take a position with the St. Anthony Falls Water Power Company in Minneapolis, and eventually became chief hydraulic engineer for ALCOA.[2]

Mortimer Barnes; association with the Sault Ste. Marie, Michigan, project was short-lived, but important. Born in 1867 at Reedsburg, Wisconsin, Barnes had acquired his initial engineering training in the practical school, working on surveys and railroad construction in Nebraska. In 1892, he enrolled in the University of Michigan, working during four summer vacations on the construction of the Poe Lock at the "Soo". He was hired in 1896 by Clergue as chief assistant engineer of the Lake Superior Power Company. Moritmer Barnes served as von Schon's chief assistant engineer from January through August 1897 and worked with Rickey and von Schon on the design of headgates, penstock bulkheads, the forebay, turbine installation options, and coffer dams. He was also placed in charge of the hydrographic survey of the St. Mary's River undertaken by the company. He, too, had considerable professional success after leaving the "Soo", serving as assistant to Joseph Ripley in designing the locks on the Panama Canal and becoming a respected name in the general area of canal and water construction.[3]

After Barnes left in 1898 or early 1899 he was succeeded by Albert Sears Crane (1868-1946). Crane had graduated from Cornell in civil engineering in 1891. His first job after graduation had been as assistant engineer for Newton, Massachusetts. He worked there for four years, then went to Brooklyn as assistant engineer in the department of sewers. Crane became von Schon's chief assistant engineer in 1898 and held the post until early 1901, when he was appointed chief engineer of the Lake Superior Power Company at Sault Ste. Marie, Ontario. Crane left the "Soo" in 1902 and served for a time as principal assistant engineer on the Chicago Drainage Canal. He then joined the J.G. White

Company in New York City as an hydraulic engineer, where he designed dams, hydroelectric power stations, and irrigation projects. He eventually became a vice president and director of the J.G. White Engineering Corporation.[4] Crane was succeeded as chief assistant engineer in early 1901 by James H. Brace. We were unable to locate any biographical information on Brace.

Unlike Rickey, Barnes, Crane, and Brace, the project's chief engineer, Hans A.E. von Schon, remained with the development from conception through construction to completion. Hans von Schon was a German emigré with a strong military background. He had enrolled by his parents in Prussian military schools from the age of 10, and he had graduated in 1869 from the Royal Prussian Military Academy in Berlin. During the Franco-Prussian War of 1870-71 he had served as a second lieutenant and been decorated with the Iron Cross. Late in 1871, however, he resigned his commission and emigrated to the United States, apparently due to inability to support himself in the style expected of a German officer and gentleman. His early years in the U.S. were difficult. At times von Schon had to support himself by hunting duck. By the late 1870s, however, he had begun to find employment with various engineering works. He was engaged, for example, on mining projects in Utah and California. In 1888 he became principal assistant to the chief engineer of coal surveys and operations in Raleigh County, West Virginia, and in April 1889 principal assistant to Lancaster Brothers Engineers and Contractors, a Southern firm. In this period he plotted land subdivisions, town sites, and designed and constructed iron furnaces. In 1890 von Schon set up his own engineering office in Virginia, and for the next few years practiced in the mid-Atlantic states, designing and constructing water power plants, electric street railways, and municipal works, acquiring, in the process, experience and skills in a wide variety of areas.

In May of 1893 von Schon joined the U.S. Army Corps of Engineers. As an Assistant Engineer he was detailed to the Lake Survey at Detroit and in July took charge of a topographical survey of the St. Mary's River. This brought him to the "Soo" and, apparently, to the notice of Clergue. It was while engaged in the closing phases of the river survey in 1896 that von Schon was engaged by Clergue to take charge of the large water power project being contemplated on the American side of the St. Mary's.[5]

Von Schon brought to the project the type of wide engineering background required for a hydroelectric project. His earlier career had provided him with experience in excavation techniques, surveying, hydraulic work, electrical instillations, as well as in structural and mechanical design. His military background may also have been considered an important qualification, for a construction project of the scale being contemplated by Clergue would have involved the management of several thousand laborers. Von Schon had never lost the military bearing and military views of discipline and method acquired in his youth. A close friend described him as a "soldierly man, firmly planted on his feet, with a voice to be heard above the din of battle". And his administration of the construction was described as "Bismarkian, dominant, efficient, and methodical".[6] Others noted that he had certain "German peculiarities" (militarism) and could not be trusted with delicate negotiations since he was too blunt and open.[7] But Clergue, presumably, intended to handle these matters himself.

The first few months of work on the Michigan "Soo" power project were primarily occupied by survey and reconnaissance work in the field and property abstract and preliminary specification work in the office. Between August and November 1896, for instance, the company's property was surveyed and stacked off, and the results plotted on a map. In addition, preliminary surveys were made for the location of a canal from Ashmun Bay to Seymour street, along with several lateral canals running from the main canal trunk to the river; 1470 soundings were taken in Ashmun Bay; a topographical survey of the entire canal line was made from the Bay to the Mission shore line; and borings were taken every 100 feet to determine the physical conditon of materials over the entire reach of the canal right-of-way. Von Schon spent most of his time working on dredging estimates, on specifications for the timber cribwork for the side walls of the intake section, and on turbine and forebay studies.[8]

During the first few months of engineering work the company's plans seem to have been uncertain. In late July 1896 Clergue talked of a 250 foot wide canal.[9] The early engineering estimates submitted by von Schon were for a 300 foot canal, but he was also asked to make surveys and estimates for a 350 foot wide channel.[10] City newspapers in November 1896 spoke of a canal 400 feet wide.[11] The inability of the canal's promoters to reach firm decisions led to some early waste and delays. Von Schon, for example, wrote to Boller, the company's general consulting engineer:

> This office has in the past done considerable work which has been entirely superceded by changes in projections due to alterations in general scope and other considerations . . . [12]

The general scheme contemplated by Clergue and his backers at this stage of the project seems to have been a main power canal running from Ashmun Bay to the Mission property below the Little Rapids, following approximately the same line as the abortive St. Mary's Company right-of-way. But instead of installing a mass of mill races and mill sites at the Mission, there would be six or seven branch or lateral canals running from a trunk line to the river at intervals of a quarter to a third of a mile from Tyson Street to the Little Rapids. A power house at the outlet of each of these branch canals would develop around 10,000 h.p.[13] This development had several attractive features. At least some of the mills would be close to town, obviating the necessity of building an entirely new town site at the Mission property. In addition, this plan would have allowed the Tyson Street branch mill to go into operation as much as a year before the lower portions of the canal were finished, thus speeding up return on investment. It also had flexibility. Costs could be cut at any time by eliminating one or more of the laterals. (See HAER drawing, sheet 2 of 8)

By late 1896 or early 1897 von Schon and his staff had completed the work of locating the canal and estimating its cost. In February Clergue wrote to W.P. Douglas, Secretary of the company, noting that von Schon had completed the plans and estimates; that they were exhaustive on three alternative propositions; and that costs would be inside two million.[14] Unfortunately we could not locate von Schon's February 1897 report, so we must speculate on what the three alternative propositions were.[15] They probably involved either varying the number and location of the lateral canals or varying the dimensions of the main canal, or a combination of both. Von Schon and Clergue personally presented the report to the company's other officials in Philadelphia in late February and early March 1897. Just what decisions were made is not clear from surviving records. Presumably the project was altered in some minor details, but not in the main.

After von Schon returned to the "Soo" his engineering staff was put to work preparing final location maps for the intake and sections I (Ashmun Bay to around Seymour Street) and II (first lateral to the river around Tyson Street) of the canal.[16] Test drillings or a test pit in March 1897, however, uncovered a large muck formation along the canal's projected path in the area of section III (second lateral to the river) and IV (third lateral to the river). The muck posed a serious problem. Von Schon had two options open to him if he hoped to continue the project as originally intended. He could either attempt to design a canal wall which would retain the muck, an exceedingly difficult and expensive proposition, or he could attempt to relocate the canal around the muck formation. The work diary indicates that both courses were investigated. First, an exhaustive survey was made to precisely locate the extent of of the muck formation. Barnes was asked to prepare a study of possible slope retaining structures for passage through the area, while other assistant engineers -- notably Barnes and Dann -- made studies of the cost of relocating section III and IV. The options were then discussed by the engineering staff, the concensus favoring relocation at an additional cost of $75,000 over original projections.[17]

The desire to avoid the technical problems and additonal expenses presented by the muck formation apparently led von Schon and Clergue to re-evaluate the original plans. What emerged was a significantly different hydropower development, one which had only a single canal and power house. At exactly what point von Schon and Clergue made the decision to abandon the multi-canal scheme for a single canal is uncertain. Evidence from the work diary suggests late April or early May 1897, for at that point the notations began to refer, specifically, to design work for a 40,000 mechanical horse power canal, where earlier entries had not indicated the size of the projected development.[18] Moreover, the diary at that same time notes computational work by the assistant engineers for the relocation of the intake section.[19] Finally, the entry for May 1 says that Barnes and Rickey, von Schon's two principal assistants, were relocationg Forebay "A". Presumably forebay "A" was originally the first of a series of forebays, with relocation necessary as it became the only forebay. Work on the revised plant was completed by May 11. Von Schon discussed the report with Clergue that day and a copy was forwarded by express to E.V. Douglass in Philadelphia.[20] This report is also lost, even though many of its details can be reconstructed.

The modified canal project replaced the 3 mile long canal from Ashmun Bay to Littel Rapids with its several branches with a 2 mile long canal with a single terminus. The new canal followed the old canal right-of-way from Ashmun Bay to Kimball Street. At Kimball it curved northward and terminated at the St. Mary's River at Tyson Street,[21] one mile above the original terminal. This plan had some advantages over the earlier one. It reduced the amount of excavation work. It almost completely avoided the hazardous muck formation. And the development gained some additional head since the canal slope would have exceeded the river slope over the last mile along the original route. Diversion to the river even closer to the main rapids would have even further increased these benefits, but government property and expensive coal dock property obviated this option.[22] (See HAER drawing, sheet 2 of 8)

The muck formation was not the only item to complicate things for the Lake Superior Power Company in the spring of 1897. Von Schon in his February 1897 report to company officials had noted that the volume of water diverted from the St. Mary's for a project of the size they contemplated (60,000 h.p. presumably hydraulic) would probably have a detrimental effect on the level of Lake Superior. This, he pointed out, would not only seriously damage lake navigation, but would also ultimately lower the head available for power development.[23] To study the probable effects on lake levels of a diversion of 30,000 c.f.s. (cubic feet per second) the company engaged, apparently on von Schon's recommendation, Alfred Noble (1844-1914).

Noble, a civil engineering graduate of the University of Michigan, was one of the nation's leading hydraulic and civil engineers. He had served his engineering apprenticeship in the "Soo" region and in the Great Lakes area. He had worked first as a recorder on the Federal Lake Survey (1867-1870) and then with harbor surveys on Lake Michigan. Between 1874 and 1882 he had served as Assistant Engineer under Godfrey Weitzel in the construction of the Weitzel Lock at the "Soo". After completion of the Weitzel Lock he had built bridges all over the country. In 1894 Noble had begun practice as a consulting engineer, operating out of Chicago. Shortly before his retention by Lake Superior Power he had been appointed by the President to the Nicaragua Canal Commission and to the Deep Waterways Commission. A future president of the American Society of Civil Engineers and winner of the John Fritz Medal of the American Institute of Mining Enginers and the Elliott Cresson Medal of the Franklin Institute, Noble was a widely known and widely respected figure with valuable contacts in both the civilian and military engineering communities.[24] Clergue could hardly have made a better choice.

Noble delivered his report to the company in May 1897.[25] He found that the contemplated power canal represented a material enlargement of Lake Superior's outlet and would lower the lake's levels significantly. At high stage the lake's level would be 1.65 feet less than the existing level; at low stage 2.1 feet lower. This, Noble observed, "would be detrimental to navigation and is not likely to be permitted".

This finding, of course, meant that the company would have to construct remedial works, that is, works which would preserve the natural levels of Lake Superior while allowing the power company to divert the desired volume of water. Noble reviewed several options -- a dike, submerged weirs, sluice gates. The simplest and cheapest solution was a dike, constructed in the present river channel at the head of the St. Mary's rapids to close off a discharge through the channel equal to the mean discharge diverted through the canal. Noble reviewed this possibility at some length. But, he found, it was inadequate. A dike designed to block a certain discharge under mean water flow conditions would keep the lake level constant for mean flow, but at low flow it would pass too much water; at high flow too little water. This would make high water levels higher; low water levels lower on the lake. The lower water levels would reduce the depth of all harbors on Lake Superior; the higher water levels would raise the level of the lake and injure docks and other lake-front properties. The table we have constructed below illustrated the inadequacy of fixed dikes as remedial works:

	Low Water	Mean Water	High Water
Normal flow from Lake Superior	60,000	75,000	100,000
Flow to be diverted by power canal	30,000	30,000	30,000
Flow through St. Mary's rapids after construction of dike to compensate for canal water under mean flow conditions (blocking c. 40% of discharge)	36,000	45,000	60,000
New flow from Lake Superior	66,000	75,000	90,000
Flow above (+) or below (-) normal	+6,000	normal	-10,000

Noble thus concluded that the simplest, easiest, and cheapest solution to the diversion problem would not be acceptable. To insure that the discharge of the canal plus the modified discharge over the rapids was equal to the normal flow at all Lake Superior levels, Noble concluded, either submerged weirs or sluice gates would have to be used. Sluice gates, he recognized, offered the best means of lake level regulation. But Noble devoted little attention to them. He pointed out that due to their relatively high cost and their liability to damage from ice in winter, submerged weirs were a better choice. Noble calculated that a submerged weir across spans 6, 7, and 8 of the International Bridge with a crest at 598 feet above sea level would afford the best and most economical means of maintaining lake levels. At low water level (601.6 ft. above sea level), he computed, the flow blocked would be 27, 820 c.f.s.; at high water level (603.0 ft.) it would be 31,470 c.f.s. The slight deficiency of compensation at low water, he found, would drop the lake level by no more than 0.19 feet, while the slightly excess blockage of the channel at high water would not raise the lake by more than 0.04 feet. While this did not represent literal compliance with the requirement that regulating works exactly maintain existing flow conditions and levels, Noble believed that it did represent substantial compliance and would prove staifactory to all concerned.

Noble recommended that the submerged weir be located just downstream from the International Railroad Bridge, relieving that the bridge piers would give the weirs some ice protection. If the bridge owners objected they could be placed slightly upstream of the bridge. Construction was to be of timber cribwork, filled with rip-rap, bolted to bedrock, and covered over with a smooth deck. It was to be at least 24 feet wide to afford sufficient stability against ice and water pressure.

With the general size of the projected power development fixed (40,000 mechanical h.p.) the general route of the canal determined; and the type of remedial works established, attention in the summer of 1897 turned towards the selection of turbines and plans for the power house. In July von Schon toured turbine manufacturing plans. Rickey and Barns were involved in the design of penstock units and the power house.[26]

By the fall of 1897 von Schon had decided to use horizontal-shaft turbines which would operate under an anticipated 16 foot head. The turbines were to be arranged in units of 500 and 670 h.p.; for a plant in which half the power would be used directly to grind pulp, half used to general electric power for transmission to other localities. The units for power pulp grinders were to develop 150 r.p.m.; the units for the electric generators were to operate at any convenient speed, with the generators driven by belting off the turbine shaft. The power house itself was to have three sections. Two wings of one story would contain turbines and pulp grinders, the ground pulp being piped to adjacent buildings containing additional pulp and paper processing machinery. The central part of the power house would be two stories tall, with turbines on the first floor, generators on the second.[27]

These designs were modified during the fall of 1897. After having Rickey make comparative studies of penstock units of 670, 570, and 500 h.p. in August,[28] von Schon decided to use a uniform 500 h.p.[29] The two-story central structure was abandoned. The new power house was to be around 85 feet wide by, presumably, about 1300 to 1400 feet long. It was a low-profile, one-story structure, more than half-submerged by the water on the forebay or canal side. The southern half of the building was taken up by turbine penstocks. The forebay area in front of the penstocks was built up to the penstock floor with clay and paved with concrete blocks. Vertical trash or ice racks situated immediately in front of the penstock entrance protected the turbines from ice and floating debris.[30] Each penstock was equipped with two draft cases. Each of these contained two horizontal turbine runners, mounted in tandem on a horizontal shaft which ran through both draft cases and a bulkhead at the front of the penstock unit. Opposite the penstocks in the north half of the building were two pulp grinding machines directly coupled to the shaft of each turbine unit. For the portion of the building to be devoted to electric power production, both direct-driven and belt or rope driven generators were being considered.[31] The exterior architecture of the projected power house was Norman. The partial elevation that survives shows a castellated tower on the east end of the power house, with castellations running along the roof line across the entire north elevation.[32] (See figs. 1 and 2)

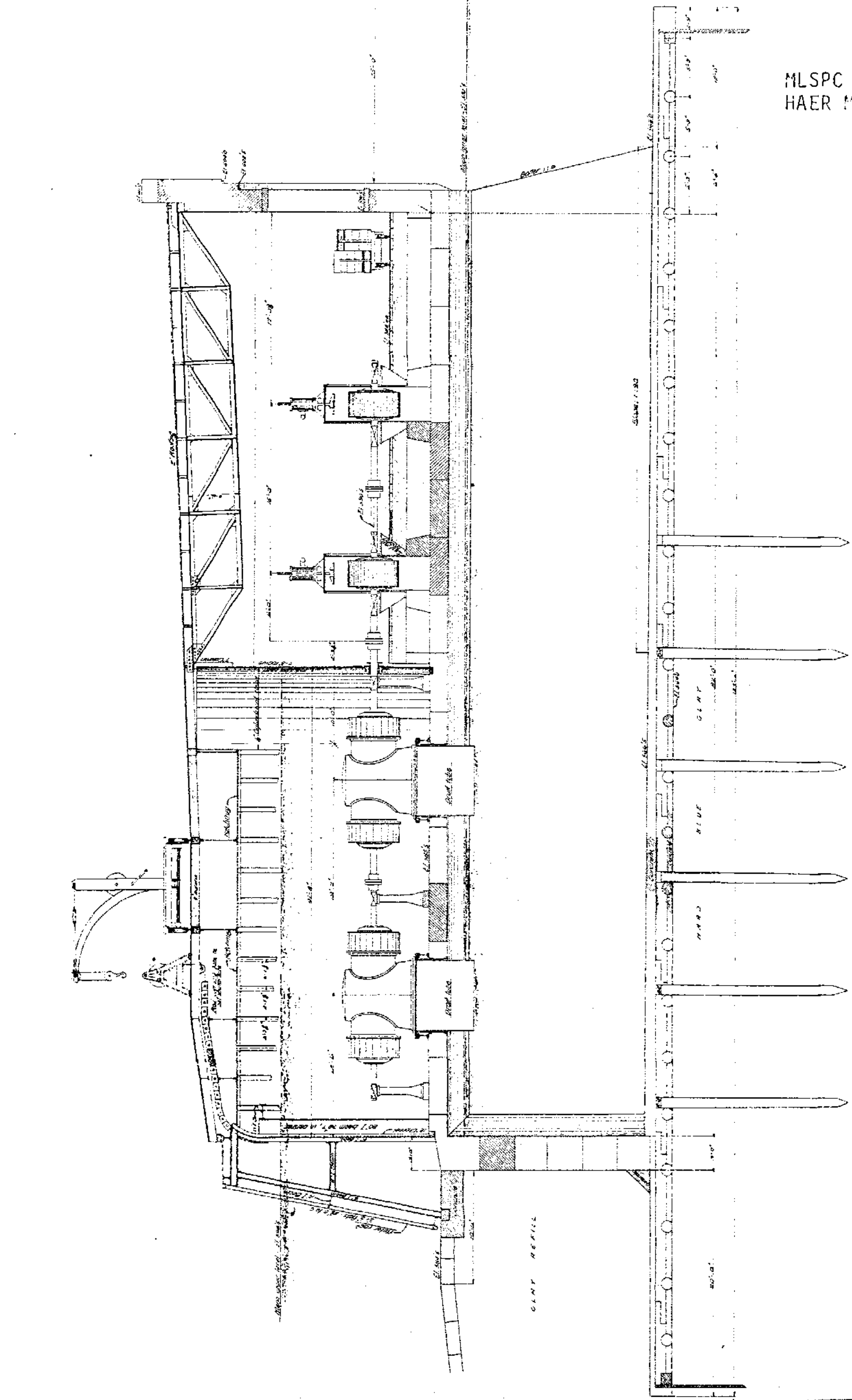


Figure 1: Cross-section of the power house as contemplated in October 1897.

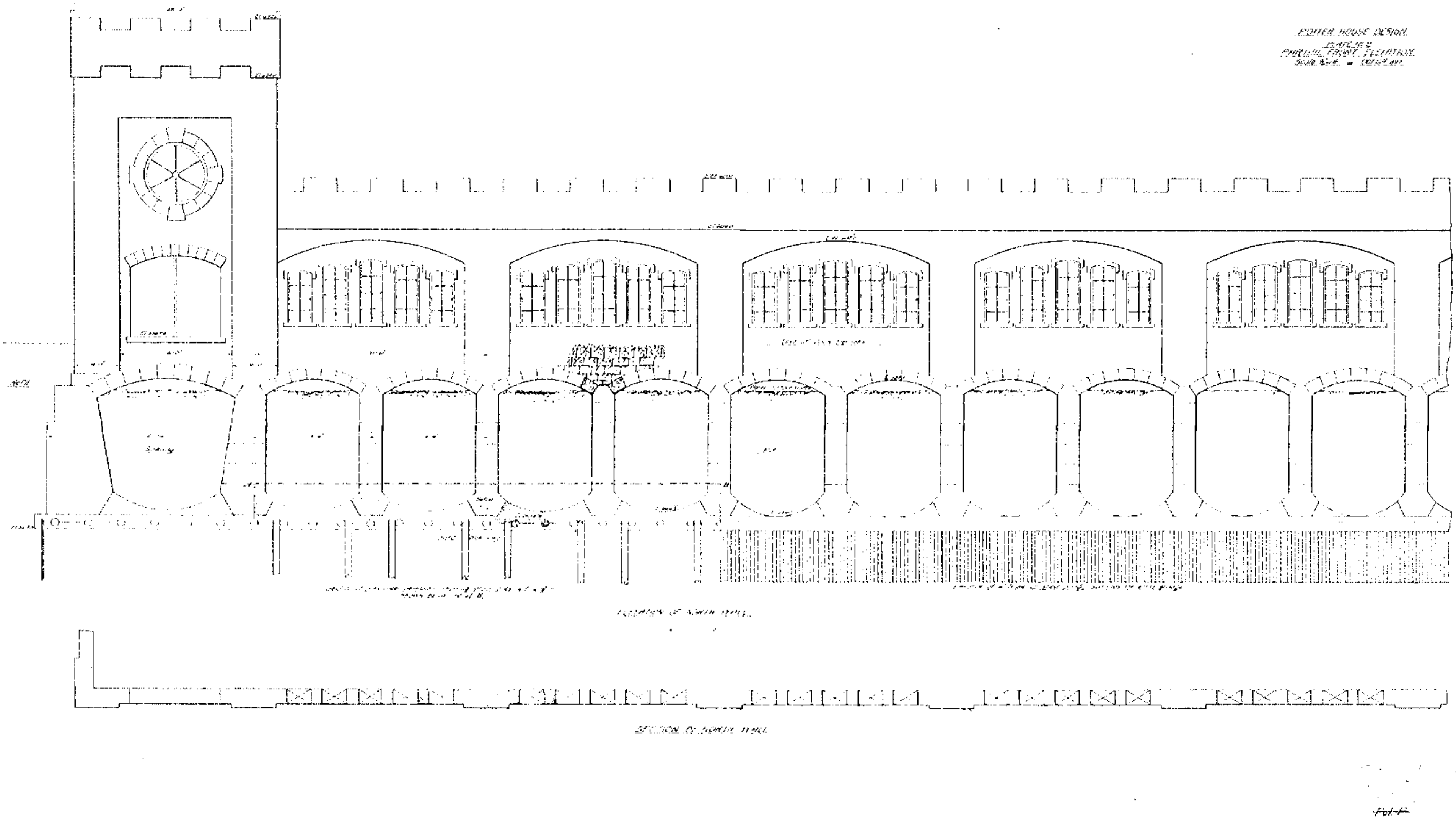


Figure 2: Partial North elevation of the power house as contemplated in October 1897. MLSPC HAER MI-1 (page 44)

While von Schon and his engineers had designed the power house and power canal to generate 40,000 h.p. for joint hydroelectric and pulp and paper production, it was still by no means certain in late 1897 that the plant would be constructed in that manner. Early in November in a letter to Westinghouse Manufacturing von Schon commented that it was still uncertain what the power would be used for.[33] At about the same time he wrote E.V. Douglas, the president of the Lake Superior Power Company, informing him that it was "absolutely essential that the exact size of the development be decided upon before the majority of specifications can be written".[34]

As a result of the uncertainties it was clear by the fall of 1897 that construction could not begin, in any case, until the following year. Clergue decided to reduce expenses through the winter of 1897 and 1898. Two rooms previously rented by the Lake Superior Company on the Michigan side were vacated. By early November von Schon had laid off all of his assistant engineers and his draftsmen, retaining only a clerk.[35] With this skelton staff he struggled along through November and early December, working on designs and estimates for power house construction. In December he informed Douglas that if he did not have the assistance of a draftsman in the near future, he would have to submit his plans in pencil.[36] He was given the additional help and by late December had his plans for the power house ready for consultation.

For the December 1897 consultation the company again retained Alfred Boller and John Bogart, the engineers who had gone over the old canal right-of-way with Clergue and Douglas in early 1895.

Alfred P. Boller (1840-1912) was a graduate of the University of Pennsylvania (1858) and Rensselaer Polytechnic (1861). He served his engineering apprenticeship as rodman, instrumentman, and topographer for the Nisquehoning Railroad. In 1863 he entered the service of the Philadelphia and Erie Railroad Company and turned his attention chiefly to structural engineering. In 1874 he opened an independent engineering office in New York, soon acquiring a large and important bridges and the construction of the foundation for the Statue of Liberty. He was through much of the mid to late 1890s the chief consulting engineer for Clergue's industrial empire. He was also widely recognized by the turn of the century as one of the country's foremost experts in structures and foundations.[37] He was quite familiar with developments on the Michigan side of the "Soo", many of von Schon's early reports being addressed to him.

Boller's associate, John Bogart (1836-1920), was of Dutch descent and had received his early education in the Albany Academy. He later attended Rutgers, where he graduated with his B.A. in 1853. Intending to pursue a legal career, he began further study, but ill-health terminated this career. He secured, instead, a position with the New York Central Railroad engineering corps and then became an assistant in the New York State Engineering Department, employed on the reconstruction and enlargement of the state's canals. He enlisted in the Union Army in the War for Southern Independence, working as a military engineer, primarily involved in the construction of heavy fortifications. On return to civilian life in 1866 he became interested in the development of parks, and served as chief or consulting engineer on park development in a number of American cities. In the 1880s he was involved in the design of several notable bridges and tunnels in the New York area, as well as with the foundation problems of large buildings. Around 1890 Bogart became interested in hydroelectric developments. He was in touch with most of the early projects and was appointed consulting engineer during the Niagara Falls development. He toured Europe in the 1890s studying hydropower development and various means of power transmission, becoming an enthusiastic advocate of electrical means of power transmission. Like Boller, Bogart was, at the time of his retention by the Lake Superior Company, one of the best respected consulting engineers in the country.[38]

In addition to Boller and Bogart a special consultant on hydraulic affairs, Alphonse Healey, was also asked to look over von Schon's plans. Healey was brought in at von Schon's request since Boller had expressed some reservations about the anticipated speed of flow through the canal.[39]

The results of this consultation was not precisely known. There seem to have been some changes in the power house design, for the closing pages of the 1897 work diary indicate that newly-hired assistant engineer C.G. Tudor was engaged in making laterations on the power house design.[40] Since high flow velocity was a feature of the final project, Healey presumably approved the precautions von Schon had taken against erosion of canal banks.

As power house designs and details were being clarified and, seemingly, finalized, Clergue continued his search for potential customers for the power. In December 1897 he had von Schon investigate the possibility of making the "Soo" a flour milling center.[41] In January 1898 von Schon at Clergue's request made inquiries about rolling mills.[42] Increasingly, however, emphasis focused on developing the power for the production of calcium carbide. As early as September 1897, in a letter to General Electric, von Schon had noted that his company (Lake Superior Power) was supplying current expected to "greatly increase" this particular branch of the industry.[43] At approximately the same time he wrote Westinghouse, commenting that disucssions were bieng carried on relating to the operation of a calcium carbide plant which would require 10,000 to 20,000 h.p.[44]

THE CARBIDE

Calcium carbide was a relatively new material. The compound had been first prepared by the German chemist Wohlerin 1862, by heating an alloy of zinc and calcium with carbon. Calcium carbide was not considered important in itself, but was valuable instead for what it yielded. Treated with water it gave off a gas (acetylene, C_2H_4) which burned with a brilliant flame. This gas had been isolated as early as 1836 by Edmund Davy, using potassium carbide, and Davy had even conceived of using acetylene as an illuminant. But the cost of producing either potassium or calcium carbide by ordinary chemical means was prohibitive at the time.[45]

Production of acetylene on a commercial scale began only in the 1890s when a more economical means was found to produce carbide compounds. The key new element was the electric furnace. Although the heating properties (and chemical effects) of an electric current and the electric arc had been recognized almost from the birth of the electrochemical cell around 1800, the first electric furnaces of any practical importance came in the nineteenth century. Earlier the large amounts of current required for heating chemical compounds to high temperatures could only be produced by a battery of electrochemical cells and this was too expensive for commercial production. The first practical electric furnaces emerged only after the development of efficient commercial generators in the period 1860 to 1880. The first commercially successful model was the work of the Cowles brothers, who used an electric furnace of their design to reduce aluminum ores.[46]

The success of the Cowles furnace in the mid-1880s, followed by the development of an even more effective commercial aluminum furance by Charles Martin Hall and Paul Heroult aroused considerable interest in high temperature chemical phenomena. Among these attracted to the field were Thomas L. Willson, a Canadian chemist, and James T. Morehead, ex-Major, Confederate States Army. Morehead owned a small hydroelectric plant at Spray, North Carolina. Part of the power of this plant was used to drive a cotton mill. Seeking to find a use for the excess power Morehead formed a partnership with Willson, who hoped to develop a means of producing aluminum superior to the Hall-Heroult process. Recognizing the high reactivity of metallic calcium, Willson planned to first isolate that metal, using the electric furnace, and then react it with aluminum ore to produce aluminum. Willson's attempt to isolate metallic calcium in 1892 in a small electric furnace at Spray failed. When he placed a mixture of slacked lime (calcium hydroxide) and tar (largely carbon) in the furnace and heated it he produced a hard brown stone-like substance -- calcium carbide -- instead of metallic calcium. When the unwanted results were discarded as waste in a nearby stream, Willson noticed that it gave off a pungent smelling vapor that burned with an intense, smokey, yellow flame. The vapour, of course, was acetylene. Willson belatedly recognized the importance of his discovery and in 1893 patented his process for producing both calcium carbide and acetylene.

At first Willson and Morehead were not sure what to do with the products of their labor. But Morehead set out with samples of calcium carbide, seeking to interest northern capitalists in the possibility of using acetylene to increase the heat and light value of the illuminating gas already being used in many large American cities. Many gas companies were already using crude oil as an enricher in their product, but the candle power of a water gas flame could be raised with acetylene far beyond anything possible with oil.

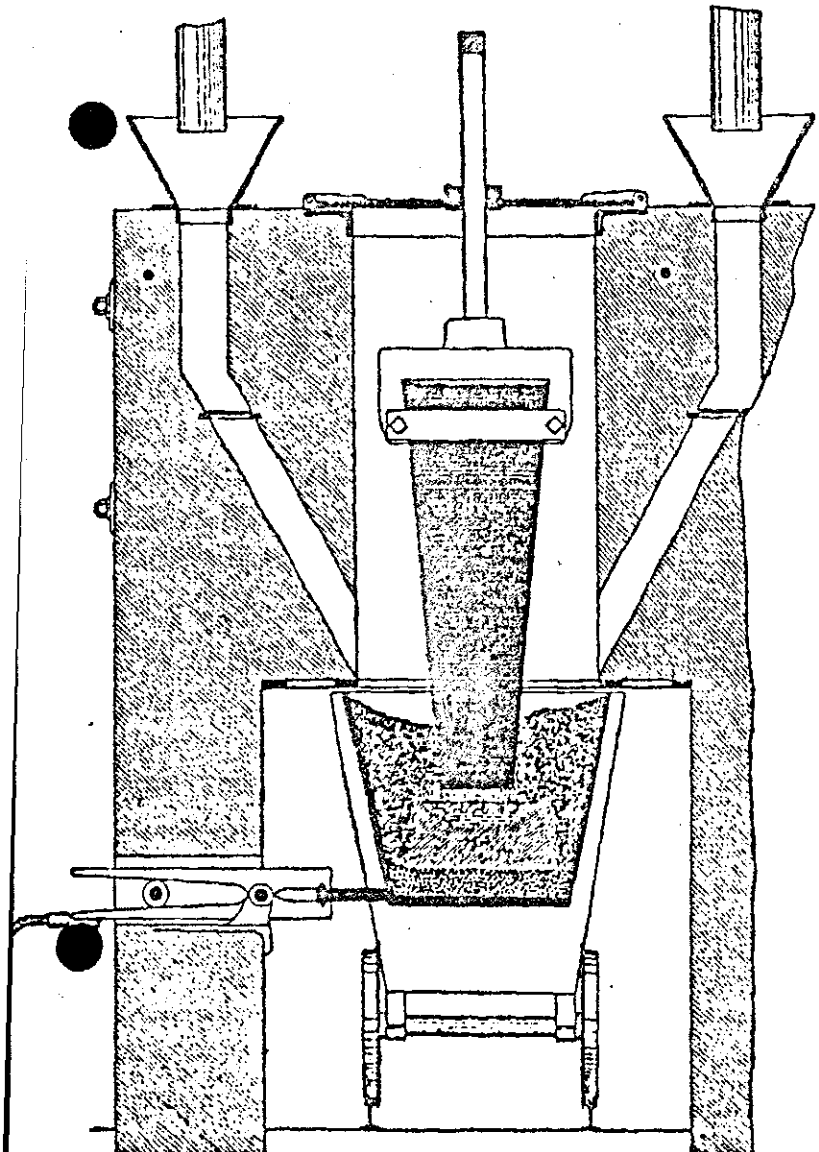
As a result of Morehead's efforts, seven carbide plants were organized, five in the United States. Early problems, both technical and managerial, caused most of them to fail. One of the few successful plants was that of the Lake Superior Carbide Company, constructed on an experimental basis in late 1896 by the People's Gas, Light & Coke Company of Chicago.[47] This plant was located in Sault Ste. Marie, Michigan, and was supplied with power by cable from the Clergue hydroelectric plant on the Canadian side of the border.[48] Indications from von Schon's records are that relations between Lake Superior Carbide and Lake Superior Power were close. Von Schon and his assistant engineers in the summer of 1897, for instance, designed docks, roadways, and a new furnace building for the carbide company.[49] The work diaries also indicate that the two organizations frequently borrowed supplied and equipment from each other.[50] Since calcium carbide production required large quantities of cheap electricity,[51] they must have seemed, from the first, one of the logical customers for the planned American hydroelectric plant to Clergue.

Calcium carbide was initially produced at the Lake Superior Carbide Works (at the corner of Peck and Meridian Streets) with a form of the original Willson carbide furnace. It was formed from an iron case, which was mounted on wheels and track. At the bottom of the iron case or box was a layer of rammed carbon. This formed one electrode of the furnace. The other electrode was movable and suspended within an enclosed brick and cast iron furnace chamber. This electrode was a large carbon rod, around 3 feet long, by 4 inches thick and 16 inches wide. The raw materials which this furnace utilized were lime and coke, crushed, ground, and pulverized into a fine powder. These ingredients could either be pre-mixed into the iron case before it was placed in the furnace, or steadily fed into the iron case as the reaction progressed by shovelling or by hoppers. In either case, the movable electrode was lowered to within several inches of the layer of rammed carbon, an electric current in the neighborhood of 2000 amperes and 75 volts was turned on, and the reaction began. The high resistance of the powered lime and coke to the passage of the electric current quickly raised the temperature between the two electrodes to around 3500 to 4000°F. At these temperatures molten calcium carbide was formed and carbon monoxide gas given off. The current flow through the mixture was maintained at a steady level as the electrode was slowly raised. After approximately three hours the electrode had reached the top of the iron case, the current was cut off, the furnace doors opened, and the container wheeled out. It was dumped out on the cement floor to cool, the half-formed carbide being separated from the compact, well-melted purer carbide. The latter, after cooling, was pecked in large iron casks for shipment. The Lake Superior Carbide plant had five of these furnaces, each of which probably absorbed from 100 to 300 h.p. when in operation.[52] (See fig. 3)

The Willson furnace was successful in producing carbide, but it was rather inefficient. The entire process was intermittent. Every time the furnace was shut down and opened to admit a new iron case or discharge an old one, an immense amount of heat was lost. This deficiency was remedied by William Smith Horry, the chief electrical engineer of the Lake Superior Carbide Company in late 1897 or early 1898.

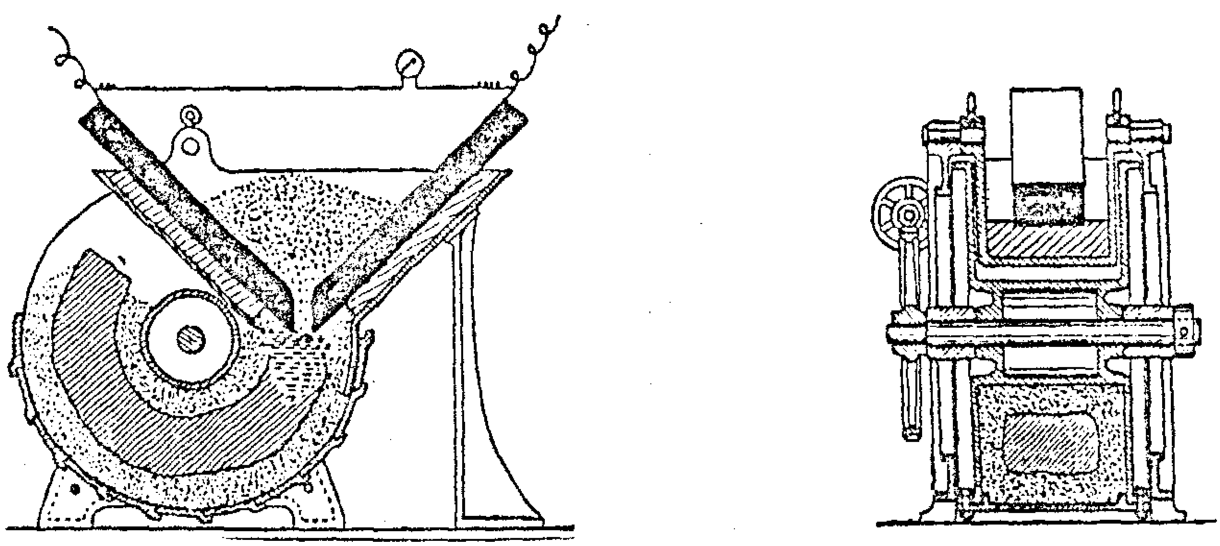
In the Willson furnace, the iron case had been held steady, while an electrode was moved. The new furnace designed by Horry operated on opposite principles. Instead of an electrode being slowly raised as the height of the carbide ingot inside increased, the electrodes in a Horry furnace were maintained at a fixed distance and the furnace chamber was moved. A Horry furnace looked like an iron spool with deeply recessed rims set on its edge. This spool, about 8 feet in diameter by 3 feet wide, was mounted so that it could be slowly rotated by worm gearing. Its outer periphery was covered by a series of iron plates which could be attached or removed. Near the top of the spool, penetrating deeply into the recessed rim, a hopper containing one part burnt pulverized lime to three parts ground coke was place. Inside the hopper were two carbon electrodes, about 6 inches in diameter, and placed so that their ends were about 9 inches apart. These electrodes were fed a current of 3500 amperes at 110 volts (c. 375 kW or 500 h.p.). When the circuit was closed the lime and coke passed out through the arc formed between the electrodes at the end of the hopper. There molten carbide was produced. As it was formed, the electrical resistance of the arc dropped, the worm gearing which rotated the spool was activated, and the rotation of the spool carried the newly-formed calcium carbide out of the arc, allowing fresh raw material to drop down into it. As the spool rotated away from the electrodes, iron covering plates were added to its periphery to hold the raw materials in the arc. These plates were removed on the other side of the furnace, after the ring of carbide cake, about 6 to 9 inches thick had cooled. The carbide was taken out and the plates left off so that the spool could once more rotate past the hopper and arc. A Horry furnace made about one revolution in twenty-four hours. It was operated continuously, producing about 2 tons of carbide per day.[53] (See HAER photos 5 through 7)

Figure 3: Early forms of calcium carbide furnaces -- Willson and Horry,



Willson Furnace for producing calcium carbide

(figures from Pring, pp. 103-05)



Horry Rotary Furnace for producing calcium carbide

The Horry furnace insured the success of the experimental carbide plant at the "Soo" and, by 1898, it was clear that acetylene could be used successfully as an enricher of illuminating gas. In early 1898 George A. Knapp and other officials of the People's Gas Company decided to expand their production facilities. In conjunction with several New York capitalists they bought up the Electro Gas Company, which held Willson's patent rights, and the only other successful American carbide plant, the Acetylene Light, Heat & Power Company at Niagara Falls. The company which emerged from these transactions they named the Union Carbide Company. The new company began, almost immediately, to enlarge its manufacturing facilities, replacing all of the older pot-type furnaces at Niagara with Horry Rotary furnaces.[54]

Union Carbide's interest in expanding their manufacturing facilities and the need of the carbide industry for cheap power thus coincided with Clergue's desire to find a major power customer before irrevocably committing himself and his company to construction of the power developmetn on the Michigan side.[55] Negotations between the carbide interests and Clergue reached a successful conclusion on April 2, 1898, when Union Carbide signed a contract with the Lake Superior Power Company for the lease of power.[56]

The terms of the contract were highly favorable to Union Carbide. In brief, Lake Superior Power agreed to construct a canal of at least 20,000 h.p. capacity and deliver 10,000 h.p. to Union Carbide within two years, 15,000 h.p. within three years, and 20,000 within four. The power company agreed to deliver this power to the turbine shaft. All generators, switchboard instrumentation, and electric furnaces for carbide production were to be provided by Union Carbide at their expense and be used exclusively in the manufacture of calcium carbide. The power company agreed to furnish, free of rent, to the carbide company space for the location of its generators and, within 30 feet of the generators, space for their electric furnaces. In addition, the power company agreed to lease additional land needed by the carbide company for a nominal sum, to furnish docks and railroad sidings, and to provide free power for the transportation of materials and men and for lighting on the power company's premises up to a maximum of 500 h.p. power 10,000 h.p. leased. Moreover, the power company agreed not to lease power to any other carbide manufacturer. Costs were set very low, $10 per horsepower per year. The lease was to extend 25 years, with Union Carbide having the option of renewing the contract in perpetuity, as well as an option to lease any additional power generated on the same terms and conditions.

The very favorable terms which Union Carbide secured probably indicates some desparation on the part of the Clergue interests to find at least one major customer for power before authorizing construction. In any case, the contract with Union Carbide irrevocably committed Clergue and his associates to construction.

The coming of Union Carbide forced von Schon and his engineering staff to once again consider and, in some cases, make major design changes in the projected plant. The power house, for instance, had been designed to accommodate pulp grinders. It now had to accommodate electric furnaces. The re-design options were handed over to assistant engineer C.G. Tudor for study. He submitted on April 7, 1898, an analysis of two options.[57] The first option was to continue to use the planned one-story structure that had been approved by Boller and Bogart in December 1897, but increase its width from 85 to 120 feet. This would allow 45 feet for the turbine bays, 37.5 feet for a generator room, and 37.5 feet for a furnace room. The second option was to maintain the projected 85 foot width, but add a second story to the power house. Tudor's analysis indicated that the second option would probably be the cheaper of the two. Adding width to the power house would mean an enormous increase in the amount of masonry and the number of steel columns, since it would be necessary to extend the thick power house foundations, the tail race walls and arches, as well as the generator-grinder room. There was also the additional cost of the partition needed between the generator and furnace rooms. The two-story unit, Tudor argued, would involve additional costs in certain areas, notably roof trusses, but taken as a whole would probably cost less and be much more saisfactory from an aesthetic viewpoint.

A letter from von Schon to Clergue in early April 1898 indicates that Union Carbide engineers were consulted very soon after the contract about possible changes in the original power house design. Von Schon reported a "thorough consultation" with Horry, who favored the one-story scheme.[58] The lower construction costs, however, seem to have persuaded von Schon and Clergue to go for the two-story structure.

Union Carbide's contract with LSPC not only led to major changes in the configuration of the power house, it also led to a reconsideration of the general layout of the power canal. Union Carbide wanted to have their storage buildings located as close to the electric furnaces as possible and feared that the space available to them near the projected power house site might be inadequate. At Clergue's request von Schon analyzed three alternative canal plans in this light in April 1898.[59] (See HAER drawing, sheet 2 of 8) The plan adopted prior to the contract with Union Carbide had called for a single canal, terminating at Tyson Street in a single power house developing 40,000 h.p., with the main line of stream flow approximately bisecting the power house. Carbide feared that without additional property to the east of the power house, their facilities would be inadequate. Von Schon agreed. An alternate scheme was to continue to run the canal up Tyson Street, but run the forebay parallel to the dock line from Tyson to Sova Streets, so that the main line of stream flow would have struck the extreme western end of the power house. This plan, von Schon estimated, would mean the loss of a half foot of head at the eastern end of the power house and would cost the power company an extra $100,000. But it would provide more land for Union Carbide. The third option which von Schon analyzed, one which the Union Carbide Company favored, was a cut-down version of the 1896 lateral canal idea. There would be two lateral canals, one along Tyson Street, the other along Ord Street, three blocks further down river. Each lateral would have a power house which would develop 20,000 h.p. One of the power houses would be used by Union Carbide; the other by the power company for non-carbide manufacturing establishments. This plan would have resulted in a half foot loss of head at the eastern power house and would have cost the power company an additional $150,000 in construction costs. The most economical option proved to be the first, with additional land being purchased east of the power house to accommodate the Union Carbide plant.[60]

Union Carbide did give some thought as late as July 1898 to locating their plant at some distance from the power house, probably at the power company's Mission property, and using high voltage transformers to transmit electrical power from the turbines to the plant.[61] But since, under the contract, Union Carbide purchased the power at the turbine shaft and would have had to purchase all the necessary power transformation and transmission equipment itself, in addition to absorbing the power lost in transmission, they decided not to follow this option.

Union Carbide's reluctant acceptance of joint occupation of the power house with the power company in the late spring or early summer of 1898 allowed von Schon to finally, after two years of changes and indecision on the part of his superiors, freeze the design of many of the elements of the Sault Ste. Marie hydroplant and begin writing up exact specifications for submission to contractors.

CHAPTER III: Footnotes

1. Work Diary, August 4, 1896.

2. "Rickey James Walter," in Who's Who in Engineering, 1st ed., 1922-23, New York, 1922, p. 1055.

3. "Barnes, Mortimer Grant," in Who's Who in Engineering, 1st ed., 1922-23, New York, 1922, p. 103.

4. "Memoir of Albert Sears Crane," American Society of Civil Engineers (hereafter ASCE), Transactions, v. 112 (1947) pp. 1430-31.

5. The primary source of biographical information on von Schon is "Memoir of Hans August Evald Conrad von Schon," ASCE, Transactions, v. 99 (1934) pp. 1340-42. Some hints of other hydroelectric projects he worked on can be gained from scattered reamrks in his Hydroelectric Practice, Philadelphia and London, 1908.

6. "Memoir of von Schon," pp. 1542. The author of the eulogy was Francis C. Shenehon, who had been in the Corps of Engineers with von Schon in the mid-1890s and described himself as a close family friend.

7. Von Schon's arbitrary military manner of running the project was not always appreciated. There is an unsigned letter from an employee to Cornelius Shields (Clergue's successor as general manager), dated August 8, 1903, for example, which states:

   > "Do as I teel (sic) you right or wrong, that is Mr. von Schon's (sic) style."

   Another letter dated July 17, 1903, also unsigned, mentions the "contempt that a certain class of our Citizens are held in by that Noble Duke Chief (sic) Von Schon". (Mf 24030)

8. For activities in the first months of operation the Work Diary is the best source of information. Also see von Schon to Clergue, November 2, 1896 (GL 1, 75-80); von Schon to Clergue, September 8, 1896 (GL 1, 5-11); and von Schon to Boller, October 3, 1896 (GL 1, 31)

9. Sault Ste. Marie News, June 6, 1896.

10. von Schon to Clergue, November 2, 1896 (GL 1, 75-80)

11. Sault Ste. Marie News, November 28, 1896.

12. von Schon to Boller, December 21, 1896 (GL 1, 264-65).

13. Sault Ste. Marie News, December 26, 1896; von Schon to Clergue, November 2, 1896 (GL 1, 75-80).

14. Clergue to W.P. Douglas, February 19, 1897 (GL 1, 490). W.P. Douglas was the company's secretary.

15. This report was apparently present at one time in the power house records, but has been missing for some time, as indicated by the following: Davis to O.B. Holley, Superintendent, November 6, 1940: "My recollection is that there was another report which dealt more particularly with the history of the project, going back to the days of the old St. Mary's Falls Water Power Company, but it is such a long time ago since I saw it that my memory is not very clear about it." O.B. Holley to Davis, November 19, 1940: unable to find the report you are talking about . (from "History of Lake Superior Power Company and Michigan Northern Power Company" file, kept by Elgin Nixon, current files of Edison Sault Electric Company).

16. Work Diary, March 5, 1897.

17. Work Diary, March 29 and March 30, 1897 began to refer to an "amended map of Canal Sections III and IV", and on April 1, 1897, to the relocation of canal Sections III and IV. The diary further indicates that Barnes on April 5, 1897, began to investigate retaining walls. References to relocation was frequent through the diary in April. See also the report of Barnes on retaining wall possibilites in the area dated April 6, 1897, and found in Reports, vol. A, pp. 39-52, and the report on "Re-Location of Canal Sections III and IV," undated, in Reports, A, 76-80.

18. Work Diary, April 29, 1897, to May 1, 1897. The diary speaks of "relocation" of the canal.

19. Work Diary, April 29 and 30, 1897.

20. Work Diary, May 11, 1897; also von Schon to E.V. Douglas, May 11, 1897 (GL 2, 339).

21. "The 'Soo' Water Power," Engineering Record, v. 38 (1898) 161; von Schon, General Report, p. 4.

22. Ibid. p. 4.

23. Soo Democrat, April 20, 1899, quoting a letter from E.V. Douglas to F.J. Firth, President of the Lake Carriers' Association dated February 21, 1899. As already noted, we were unable to find a copy of von Schon's February 1897 report despite extensive inquiries.

24. "Memoir of Alfred Noble," ASCE, Transactions, v. 79 (1915) pp. 1352-1365 and ff.

25. "Report to Lake Superior Power Co. on Remedial Works at head of St. Mary's Rapids, May 25, 1897," (OCf, A. Noble, Reports); also Reports, A, pp. 116-55.

26. For summer activities in 1897 see the Work Diary for that year.

27. von Schon to S. Morgan Smith Co., May 10, 1897 (GL 2, 332-33); von Schon to Dayton Globe Iron Works Co., May 17, 1897 (GL 2, 364-65). Von Schon had been making inquiries about horizontal turbines which could develop a minimum of 700 h.p. per penstock unit, speed immaterial, and about turbines for a second unit which could develop a minimum of 550 h.p. at 150 r.p.m., fed by feed pipe under 16 foot head. A 40,000 h.p. plant which would use half of each was planned. Von Schon to Dayton Globe Iron Works, April 29, 1897 (GL 2, 272-73).

28. Work Diary, August 28, 30, 31, and September 1, 1897, for Rickey's studies. Von Schon to A.F. Sickman, September 23, 1897 (GL 3, 409) indiactes that turbine units of 500 h.p. had been adopted.

29. See "Discussion of stability of 500 h.p. unit Penstock Installation against Sliding," by J.W. Rickey, October 7, 1897 (Reports, A, 176-181); Rickey to von Schon, October 14, 1897 (Reports, A, 182-85); Rickey to von Schon, October 16, 1897 (Reports, A, 201-05). All of these indicate that a 500 h.p. penstock unit was being adopted.

30. Original inked drawing dated October 15, 1897, and numbered 232 in Edison Sault drawing collection, Folder 5, Pocket 3.

31. von Schon to General Electric, October 15, 1897 (GL 4, 3); also von Schon to Westinghouse Electric, October 15, 1897 (GL 4, 2).

32. Original inked drawing in Edison Sault drawing file, numbered 231, filed in Folder 5, Pocket 3.

33. von Schon to Westinghouse Electric, November 1, 1897 (GL 4, 55).

34. von Schon to E.V. Douglas, November 16, 1897 (GL 4, 78-80).

35. von Schon to Clergue, November 6, 1897 (GL 3, 459).

36. von Schon to E.V. Douglas, November 21, 1897 (GL 4, 124).

37. "Memoir of Alfred Pancoast Boller," ASCE, Transactions, v. 85 (1922) pp. 1653-56.

38. "Memoir of John Bogart," ASCE, Transactions, v. 88 (1925) pp. 1346-50.

39. von Schon to E.V. Douglas, November 21, 1897 (GL 4, 124-26); von Schon to Clergue, December 13, 1897 (GL 4, 300).

40. Work Diary, December 28-30, 1897.

41. "Is Sault Ste. Marie a favorable point for grinding wheat in transit as compared with Minneapolis," Reports, A, 236-80; also von Schon to Case Manufacturing Co., December 1, 1897 (GL 4, 194-95).

42. von Schon to Frank-Kneeland Machine Co., January 22, 1898 (GL 5, 19).

43. von Schon to General Electric Co., September 14, 1897 (GL 3, 359-60).

44. von Schon to Westinghouse, November 1, 1897 (GL 4, 55).

45. Vivian B. Lewis, Acetylene, Westminster and New York, 1910, pp. 1-62, for the early history of acetylene and calcium carbide.

46. For the early history of the electric furnace see ibid., pp. 173-195; Archibal Stansfield, The Electric Furnace, 2nd ed., New York, 1914, pp. 1-16; J.N. Pring, The Electric Furnace, London, 1921, pp. 1-15.

47. For the origins of the calcium carbide industry in the United States see Lewis, Acetylene pp. 195-197, and Williams Haynes, ed., American Chemical Industry, v. 6, Toronto, etc., pp. 430-432.

48. Sault Ste. Marie News, August 1, 1896; Soo Democrat, December 24, 1896.

49. Reports, A, 112-14, 156-75; also some letters, e.g. von Schon to Clergue, July 31, 1897 (GL 3, 154).

50. "Property of the Lake Superior Power Company in use at Carbide Works," (GL 1, 157); Work Diary, January 5, 9, 12, and February 2, 1897.

51. "The Calcium Carbide Industry as a Factor in Water Power Development," Engineer (U.S.A.), v. 39 (1902) 561; Lewis, Acetylene, p. 284.

52. The Willson type of calcium carbide furnaces is described in a number of places, among them: Lewis, Acetylene, 195-202, 286-287; Pring, Electric Furnace, pp. 102-104; Stanisfield, Electric Furnace, pp. 289-300; Joseph W. Richards, "The Electrochemical Industries of Niagara Falls," Electrochemical Industry, v. 1 (1902) 22; and Soo Democrat, December 24, 1896, describing the Willson-type furnace in the Sault Ste. Marie experimental plant.

53. For material on the Horry furnace see Lewis, Acetylene, pp. 207-209; Pring, Electric Furnace, pp. 104-105; Stanisfield, Electric Furnace, pp. 302-303; Richards, "Electrochemical Industries," p. 23.

54. For a summary history of Union Carbide see Haynes, American Chemical Industry, v. 6, pp. 429-438. The early history of the company appears on pp. 430-432.

55. Soo Democrat, April 14, 1898.

56. Contracts, 146-157.

57. "Report on new Power House Designs for Electric Furnace Plant" by C.G. Tudor, April 7, 1898, Reports, B, 108-117.

58. von Schon to Clergue, April 4, 1898 (GL 5, 359).

59. von Schon to Clergue, April 21, 1898 (GL 5, 480-81); von Schon to Clergue, April 30, 1898 (GL 6, 37); von Schon to Clergue, April 30, 1898 (Reports, B, 130-32); Clergue to Knapp, April 21, 1898 (GL 5, 481).

60. Soo Democrat, April 27, 1899, noted that the company had purchased the Ord property. This included 475 feet of river frontage east of the power house.

61. von Schon to Westinghouse Electric, July 19, 1898 (GL 6, 481). Von Schon to Clergue, August 1, 1900 (PL 4, 45-47) indicates that Union Carbide reconsidered this option again at a later date.

CHAPTER IV:

FINALIZING THE DESIGN OF THE HYDRO (1898-1899)

Three basic decisions, all finalized in 1898, determined many of the unique features which ultimately were incorporated into the Michigan Lake Superior Power Company hydroelectric plant.[1] They were:

1. The decision to accept a 260 foot wide right-of-way through the city rather than pay inflated prices to secure a 450 to 500 foot right-of-way.

2. The decision to build a plant to develop 40,000 h.p. after turbine and generator losses were deducted.

3. The decision to design the plant to power either pulp grinders or Horry carbide furnaces or both.

The flow chart on the following page, in conjunction with the material contained in the text of this chapter, indicates just how a number of the constructions in the hydropower development were influenced by these decisions.

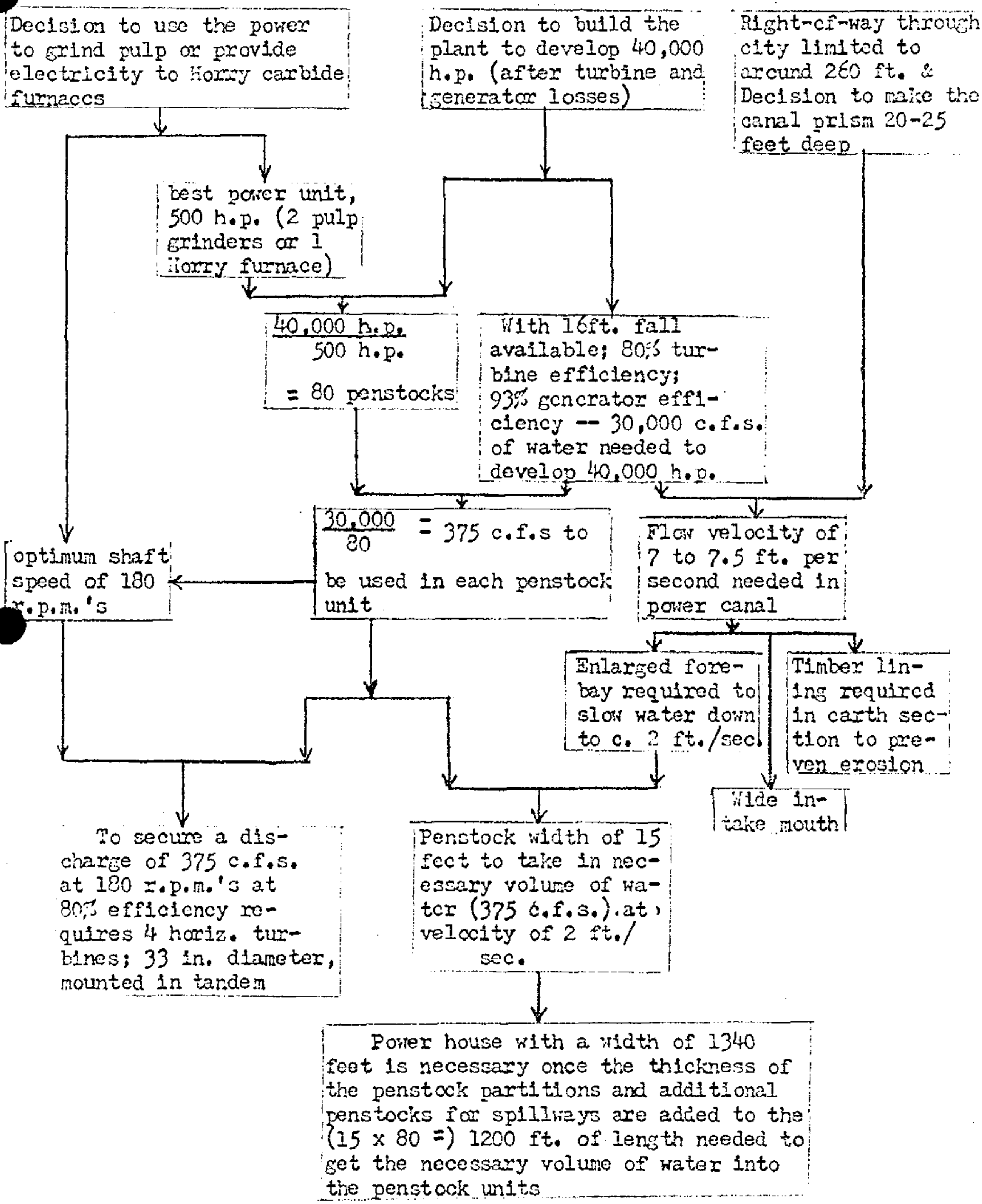
THE POWER CANAL

The route of the MLSPC canal followed the right-of-way inherited from the St. Mary's Falls Company for over 1½ miles, up to the muck formation. From that point on, as already noted, it curved northeast. (See HAER drawing, sheet 2 of 8). The canal terminated after a distance of around 2¼ miles at a power house located close to the shore line of the St. Mary's River. It would undoubtedly have been better to locate the entire power development out in the rapids. The fall lost due to the slope given the long power canal and the friction of the canal sides would have been significantly reduced. But other local interests had already installed a small hydro-electric plant in the rapids and owned all riparian rights in the area, so thia option was unavailable.

The dimensions of the power canal prism were determined by two conditions -- the maximum right-of-way obtainable at a reasonable cost and the desire to generate 40,000 h.p. The right-of-way obtained from the St. Mary's Company varied from 150 to 400 feet. Clergue several times indicated interest in a canal 400 feet wide. But he found the prices demanded by owners of the additional land he needed excessive. The maximum right-of-way obtainable at a reasonable price over the entire length of the canal was only around 260 feet.[2] This meant, allowing for slopes and embankments, the greatest canal width which could be used was only around 200 to 220 feet. Apparently von Schon's computations indicated

Table 1:

Flow Chart, Design of Michigan Lake Superior Power Company Hydroelectric plant, 1896-1898



that the most economical depth for such a canal was around 22 to 23 feet.[3] This gave the canal prism a cross section of around 4500 square feet. To develop the desired 40,000 h.p. at an estimated 16 foot head,[4] after turbine and electrical losses were deducted, required around 30,000 c.f.s.. To get such a volume to the power house through the projected canal prism compelled von Schon to adopt a flow velocity (allowing for frictional losses) for the canal of around 7 to 7.5 feet per second (the velocity actually developed in the completed canal was around 6 to 6.5 feet per second.). This was unusually high for a power canal, but unavoidable because of the right-of-way problem and the projected scope of the development.

The power canal (see HAER drawing, sheet 3 of 8) was divided into five sections: intake, Section I (rock section), Section II (sand section), Section III (clay section), and forebay.

The intake was approximately 2400 feet long and led water into the canal from the St. Mary's River above the rapids. The canal at the mouth of this section was some 950 feet wide and only gradually narrowed to 200 feet. The enlarged intake mouth was made necessary by its location and by the high flow velocity planned for the standard canal prism. The entrance to the canal was along the established navigation channel, just above the government ship canal. An intake velocity of 7 to 7.5 feet per second would have created cross currents hazardous to shipping. The wide mouth (950 feet wide by 20 feet deep) enabled von Schon to divert water at a speed (around 2 feet per second) slow enough to avoid endangering the shipping which passed the opening of the canal.[5]

Most of the intake section projected beyond the natural shore line well into Ashmun Bay, a rather shallow body of water from 3 to 5 feet deep. Sub-soil conditions along the section varied widely, so it was divided into two parts -- upper intake and lower intake. In the upper intake the soil down to the required channel depth (20 feet) was largely a mixture of sand, clay, gravel, and an occasional boulder. Here dredges could do the necessary excavation work. For the lower 1400 feet of intake, however, much of the projected channel travelled through solid rock which could only be excavated dry. This was to be accomplished by constructing a large coffer dam at the boundry between the upper and lower intakes and a smaller dam where the intake entered Section I (rock section). The area between these dams could then be pumped out so that drills and steam shovels could be brought in.

Von Schon planned a special bulkhead warf for both sides of the intake at its mouth. His specifications called for these to be constructed from cribs, built up from lobs 12 inches in diameter. The timbers running parallel to the canal were to be 30 feet long. Transverse timbers 16 to 18 feet long were to be spiked to these at 5 foot intervals, with layers of both added under the crib extended several feet above the water line.

Table 2:

The Power Canal of the Michigan Lake Superior Power Company

Section	approx. length	width (at water surface)	depth	soil conditions	lining	prism shape
Intake	2400'	950 to 200'	20'	sand, gravel, and clay	rock-filled timber cribs on sides; nothing on bottom	rectangular
I	2700'	200'	22'	largely Potsdam sandstone	natural sandstone with some concrete masonry	rectangular
II	3000'	216'	23'	largely sand	timber ***	trapezoidal
III	3000'	216'	23'	largely clay	timber	semi-elliptical*
Forebay	300'	216 to 1350'	23'	largely clay	timber**	trapezoidal

Note: All figures approximate

*originally trapezoidal; modified to semi-elliptical in course of construction

**originally only the sides were timber-lined; the bottom (save for the upper forebay) was left unlined; bottom lined completely with timber in 1903

***for more than half of Section II the bottom of the canal prism is rock and only the sides are timber lined

Approximately half-way up the bulkhead cribs were to be faced with white pine planks. In addition to the main bulkhead crib structure, anchor cribs 20 feet long and 22.5 feet wide, rising to the water level, were to be built and placed to the rear of the main bulkheads for support.

The side wall retaining cribs (see HAER photo 29) used for the canal walls on the remainder of the intake (both upper and lower parts) were similar to the bulkhead warf cribs. They were 30 feet long by around 17 feet wide. But the transverse timbers were only laid on 7 foot centers and no anchor cribs were used. The retaining wall cribs, moreover, were only 18 feet high and so fell 2 feet below the water's surface. A row of 12" x 12"s were bolted to the top of the water face of these cribs and behind them filling material was piled to around 5 feet above the water line. Where the fill was sloped down to the top of the crib work, it was lined or paved with stone.[6]

The areas behind the crib work on both the north and south sides of the intake section were to be filled with excavated material from the canal. Ultimately almost 60 acres of land were claimed from Ahsmun Bay and the general configuration of the shore line in the are completely altered. (See HAER drawing, sheet 2 of 8, figs. I and V)

Section I or the rock section of the power canal began at approximately the old shore line of Ashmun Bay. By this point the channel had been narrowed from 950 feet to around 220 feet. This was expected to be the most difficult portion of the route to excavate. The planned stream velocity (7 to 7.5 feet per second) through its 200 x 22 foot rectangular cross section required no special precautions. In fact, von Schon seems to have selected a canal prism 22 to 23 feet deep in part because the flow speed which resulted could be maintained safely in the rock cut without special constructions.[7]

The sides and bottom of the canal prism in the rock cut were to be unlined. Where the stone was in bad condition, however, von Schon planned to line it with masonry. And where the natural rock formation fell below the height of the canal banks, he planned to use masonry retaining walls.

For almost half of its length the canal passed not through rock, but through sand and clay. In these sections the projected velocity of flow would have quickly eroded away the sides and bottom of the canal. Von Schon's solution to this dilemma was ingenious. He designed a trapezoidal timber lining to protect about 6000 feet of the power canal, a construction considered by one engineering magazine to be "wholly unprecedented".[8] Bearing piles spaced around 10 feet apart were to be driven in rows spaced about 5 feet apart running across the bottom of the canal and up its 45^{o} sloped sides. Sills of 12" x 12" timber were to be spiked to these piles. The space between the sills would then be filled with clay puddle, to inhibit leakage, and on top of the sills a 3" x 4" timber lining would be nailed. This lining was to terminate a foot or two below the water line. Several layers of 12" x 12" beams laid on top of each other would follow and then stone paving on a clay-filled bank sloped backwards at approximately a 45 degree angle. The water level was to be just above the top of the 12" x 12"s.[9] By keeping the timber lining completely underwater von Schon hoped to preserve it indefinitely, since it is only through alternate exposure to air and water that timber rots. (See HAER drawing, sheet 3 of 8)

The timber lining which von Schon planned for the earth sections of the canal had a dual purpose. Besides protecting the banks from erosion, it also reduced the friction between the water and the canal. Von Schon estimated that the amount of fall lost to friction in the timbered portion of the canal would be less than that lost to friction in the rock section, even though the former was more than twice as long.[10]

As the canal passed Portage Street, von Schon planned to enlarge its cross section to form a forebay, a sort of mill pond. The gradual expansion of the cross-sectional area of the canal here would slow the water down in preparation for its entrance into the turbines. Hydropower practice was to drop the velocity of water at the turbine intake to around 1-2 feet per second, since higher intake velocities caused disturbances in the turbine runners, vibrations, and wear on the turbine chambers.[11] There were other good reasons for dropping the speed of the water before it entered the power house. The lower velocity gave the water a chance to deposit materials carried along in suspension.[12] It also reduced the pressures which the combination dam and power house would have to withstand. Finally, it enabled von Schon to reclaim some of the head or fall he had lost in the power canal.[13] The head lost due to the velocity of the water can be approximately computed from the equation $h=v^2/2g$, where is the head or fall lost because of the velocity of the water; v is the water velocity; and g is the gravitational constant. This equation indicates a loss of almost a foot of head at the standard canal velocity of 7 feet per second, versus a loss of less than an inch when the water is slowed down to 2 feet per second. Von Schon planned to line the forebay area with timber, but used only unfinished logs instead of plans on the forebay embankment walls.

THE TURBINE INSTALLATION

The basic decisions which fixed the size and nature of the canal also played a major role in turbine selection and penstock design. For example, the decision to design the plant for pulp grinders and Horry furnaces fixed the unit output per penstock at 500 h.p.[14] Pulp grinders required about 250 h.p. Since two could quite easily be installed on an extended turbine shaft, 500 h.p. penstock units were a natural choice. For general hydroelectric power generation it was not so natural a choice, and before the Union Carbide contract von Schon considered electrical generating units ranging from 500 to 1000 h.p.[15] The early Horry furnaces, however, were rated at about 375 kW or 500 h.p.,[16] so after April of 1898 the basic penstock power unit for the entire plant was frozen at 500 h.p.

The anticipated scope of the power development (40,000 h.p.) and the establishment of the basic penstock unit at 500 h.p. meant that the power house would require a minimum of 80 penstocks. And since these penstocks would be expected to discharge a total of 30,000 c.f.s., each would have to discharge at least 375 c.f.s. (30,000 - 80).

A discharge of this magnitude under the low head (16 feet) which von Schon had at the power plant location was somewhat of a problem. The blades of pressure turbines, for optimum performance, must have a peripheral speed around 75% of the theoretical velocity of the water flowing through them. Under a 16 foot head, the water velocity is rather low (c. 30 feet per second). A single large diameter turbine runner operating under that head could have discharged the requisite quantity at high efficiency. But the shaft velocity of this wheel would have been very low.

The shaft speed desired by von Schon was 180 r.p.m.'s. This speed, he says, was determined by the requirements of pulp grinding machinery and electric generators.[17] The need to use 375 c.f.s. per penstock unit, however, was probably equally important.

For electric generators a much higher speed would have been better (say 200-250 r.p.m.'s). High speed generators are more efficient than slow speed generators and considerably cheaper because they are small than slow speed units of the same output. To get high shaft velocity under the low head conditions at the "Soo" would have required the use of very small diameter turbines. These would have had a low discharge rate and hence a low power output and von Schon would have had to use a large number of them in each penstock unit to secure 500 h.p.

The 180 r.p.m. shaft velocity seems, therefore, to have been a compromise between reasonable turbine and reasonable generator costs. A higher speed would have reduced the cost of the generators, but would have greatly increased the number and hence the cost of the turbines. A lower speed would have reduced the number of turbines needed per penstock unit, but increased generator costs.[18] The compromise speed, moreover, was adequate for pulp grinders.

Von Schon, of course, had the option of using a slower turbine shaft speed and driving high speed generators by gearing or belting instead of directly. But gearing or belting would have resulted in a power loss of around 10%, and apparently von Schon found this unacceptable.

The choice of turbine type (horizontal), turbine size (around 33"), and number of runners per penstock (4) followed naturally from the choice of 180 r.p.m. shaft speed, the 375 c.f.s. discharge required per penstock, and the desire to directly link generators and pulp grinders to the turbine shafts. Von Schon found that to get 180 r.p.m.'s under a 16 foot head at good efficiency he had to use a turbine runner of around 33 inches diameter. But a turbine unit of this size discharge only around 100 c.f.s. and generated only around 125 h.p. To secure the desired 500 h.p. per penstock unit he had to place four of these runners in tandem in each penstock. This arrangement was not uncommon in turn of the century low-head hydroelectric plants. In fact, one of the big advantages of horizontal over vertical-shaft turbines was the possibility of mounting more than one turbine runner on the same shaft without loss of head.[19] By mounting multiple runners one could either secure an increase in speed with the same power output, or, as in the Sault Ste. Marie unit, an increase of power with the same speed as a single unit.

Von Schon arranged the turbines in pairs. Each pair was to be housed in a cast iron draft case which discharged into a centrally-located, conical draft tube. One turbine runner was to be placed at the downstream end of the draft case; the other at the upstream end. The draft case and tube arrangement was used to set the turbines above the tail water for ease of maintenance and repair without suffering loss of head. Each pair of turbines was keyed into a steel shaft. The outer shaft was 5.5 inches in diameter; the inner one 7.25 inches. They were bolted together with forged couplings. These shafts were to be supported within the two draft cases at the ends and at the center. Additional support was provided by cast iron pedestals fixed to the floor of the penstock at the upstream end of the outer draft case and between the two draft cases. A third pedestal supported the shaft just beyond the steel-plate bulkhead which blocked the water at the downstream end of the penstock. The 7.25 inch turbine shaft penetrated this bulkhead through a stuffing box. Each of the runners was to be equipped with its own pivoted-vane control gate, but all four gates in any unit were to be controlled by a single shaft which, like the turbine shaft, projected horizontally through the bulkhead.[20] (See HAER drawing, sheet 6 of 8)

The width of the chamber or penstock in which each set of four turbines were to be placed, and hence the length of the power house, was determined by the velocity of water in the forebay area and the required discharge per unit (375 c.f.s.) The expansion of the canal prism in the forebay had been designed to slow the water down to around 2 feet per second. In order for a penstock to take in 375 c.f.s. at 2 feet per second over a height of around 13 feet, a width of 15 feet between partition walls was required.[20a]

Once the width per penstock unit was determined, the length of the power house followed. For 80 penstocks a distance of 80 x 15 or 1200 feet was required, and by the time the thickness of the penstock partitions and extra penstock units for spillways were added to this figure, a power house of extraordinary length, slightly more than a quarter of a mile, was necessary. (See HAER drawing, sheet 4 of 8)

Von Schon recognized that the turbine installation was the heart of a hydropower plant and devoted considerable attention to it. As early as 1896, for example, he inquired about the results of experiments made at the Holyoke, Massachusetts, test flume.[21] Holyoke in the late nineteenth century had become the premier turbine testing facility in the United States and most turbine manufacturers tested their products there. While the Holyoke tests were one of the best guides available for turbine design, von Schon was somewhat sceptical. Holyoke tests, he felt, were conducted under special refined conditions which tended to give much higher efficiencies than could be actually realized in practice. Moreover, the Holyoke flume was designed to test only vertical-shaft turbines, and von Schon believed that results from tests on single turbines set on vertical shafts could not be relied on for the installation he planned -- multiple horizontal-shaft turbines mounted in tandem.[22]

Von Schon had assumed a turbine efficiency of 80% or more in designing the canal prism and penstock units of the "Soo" plant, so it was essential that any turbines purchased by the company achieve at least this figure. Since available Holyoke tests could not guarantee this, von Schon contemplated writing into the turbine specifications a provision for in-place testing in the Sault Ste. Marie plant. Any turbines purchased would be tested for three months in the plant. No money would be paid to the manufacturer until after the trial period. For every 1% below 80% efficiency the manufacturer would have 10% deducted from the contract price; for every 1% over 80% there would be a bonus of 5%. This idea was forwarded to twelve turbine manufacturers for comment in 1898.[23] The results were not favorable.

By the end of 1898, after some consultation with the chief engineer at Holyoke, the test flume agreed to modify their facilities to test a pair of horizontal wheels.[24] In the specifications which von Schon prepared for the turbine installation in late 1898 manufacturers were to guarantee that their turbines would develop an 80% efficiency as determined by tests at Holyoke conducted by the company, rather than in in-place trials. The penalty-bonus clauses were removed.

Turbine specifications were sent out in either December 1898 or January 1899, with bids due by April 1. The initial results were disappointing. Only three manufacturers bid, and several of the bids were irregular, that is, they did not fully meet the specifications. Von Schon claimed that the large size of the contract involved (turbines for 40 penstocks) deterred some, since an order of that size would have taxed the facilities of even the largest manufacturer, especially since delivery was to be completed by January 1, 1901. Another feature of the initial specifications which manufacturers found objectionable was the requirement that they provide a trial turbine for testing, with no certainty of receiving compensation, and the possibility of receiving very damaging publicity if the tests were unsatisfactory.[25]

Revised specifications were issued on April 10, 1899, with more favorable results. The low bidder was the Webster, Camp and Lane Machine Company of Akron, Ohio. Webster, Camp and Lane were not regular tubines manufacturers. In order to deal with a contract of the size contemplated for the "Soo" they had entered into a special agreement with the J. and W. Jolly Company of Holyoke, a very well-known turbine manufacturer. Jolly was to provide Jolly-McCormick turbine runners; Webster, Camp and Lane were to manufacture everything outside the turbine proper and install the equipment.[26] Webster, Camp and Lane guaranteed the performance called for in the specifications: 564 h.p. at a 16 ft. head at 180 r.p.m/'s, with a discharge of 391 c.f.s. and at least 80% efficiency. They proposed to achieve these results with four 33-inch diameter Jolly McCormick turbines mounted in tandem in draft cases.[27] Negotiations between MLSPC and Webster, Camp and Lane on the specific of their proposals went on through the summer and fall of 1899. A formal order for 40 penstock units (160 turbines) was placed on November 8, 1899. Under contract terms Webster, Camp and Lane were to have five turbines delivered and installed within six months; the entire installation completed within 34 months. One unit of 2 runners was to be sent to Holyoke for testing and on the results of this test the power company conditioned its acceptance of the units.[28]

POWER HOUSE FOUNDATION AND SUB-STRUCTURE

Foundations are usually the most critical single element in hydraulic construction, the one area where mistakes are often fatal and certainly not easy to correct. The site selected for the MLSPC power house foundation was in the shallows of the St. Mary's River. Eight test borings were made at the site in January of 1897 to determine the subsoil conditions. All eight indicated around 15 feet of silt, sitting on a foot or two of gravel, overlying a bed of hard clay 20 to 30 feet thick. Under the clay was bed rock. The results of the eight borings were so uniform that von Schon and his assistants assumed a fairly regular formation of these materials over the projected area of the foundation.[29]

Von Schon planned to place the foundation at a level some 16.5 feet below the surface of the St. Mary's River, wholly on clay. This meant that the entire site of the power house would have to be surrounded by a coffer dam and drained during construction. The silt and gravel overlying the clay would then be excavated. Von Schon believed that the clay bed was strong enough to support the weight of a power house placed on a 125 feet wide by 1400 feet long foundation. Around 1050 hardwood strain piles averaging a little over 16 feet in length, anchored in the concrete foundation by a timber grillage and driven through the clay were to provide stability against the hydrostatic pressure of the 16 feet of water at the front of the building.[30] As we shall see later, substantial modifications were to prove inadequate.

Directly over the foundations von Schon planned to install 85 tail races, enclosed tunnels which would lead water discharged through the 80 sets of turbines and 5 spillways back to the St. Mary's.[31] Each of these races or tunnels was to be approximately 93 feet long by 16.5 feet wide (on centers) by 16 feet high. The floor of each race and the base of the walls which separated one race from another were to be of monolithic concrete. The arched roofs over the pits were also to be of monolithic concrete. But the 3-foot thick partition walls, as well as the wall which endosed the upstream portion of the tail race were to be built of pre-moulded concrete blocks.[32] (See HAER drawing, sheet 6 of 8)

The decision to use pre-moulded blocks for the walls came only after considerable deliberation by von Schon and his assistants. Von Schon recognized that pre-moulded blocks would cost more than monolithic poured concrete. But he felt that there were major advantages. Pre-moulding, for example, would allow concrete work to begin while excavation and foundation work on the power house were still going on. The pre-moulded blocks would have a change to age. Once in place they could be built on immediately. Poured concrete walls would have to set for 20 to 30 days before it was safe to begin loading them. Von Schon believed these advantages, plus ease of repair, would offset the higher costs.[33]

The concrete specifications written by von Schon in 1898 were based in part on tests carried out by his staff in the spring and summer. In late 1897, in the midst of ordered staff cut backs, von Schon wrote Clergue asking that he be allowed to establish a facility to test cements and concrete mixtures. He noted that while the engineering literature had considerable material on the strength of various concretes, there were none available on the particular aggregates available at Sault Ste. Marie.[34] He wrote Douglas early in 1898 that reliable test results on the strength of concretes made from local materials would, in terms of material ultimately saved, more than compensate the company for the cost of testing facilities.[35] Von Schon was granted his request. A testing machine was purchased and during the late spring and summer of 1898 extensive tests were made on various cements and on concrete mixtures. (See HAER photo 8)

Von Schon found, as a result of these investigations, that the best results were obtained when the materials which formed a concrete aggregate were mixed in a definite order:

1st: the sand and cement mixed dry
2nd: mortar prepared and mixed separately
3rd: clean, sharp stones added to the mortar
4th: the two mixtures, with proportions fixed by weight, instead of volume, mixed slowly and uniformly

Machine mixed concrete, von Schon believed, could not match hand mixed concrete unless it imitated these procedures. Von Schon thus required the concrete for the sub-structure of the power house to be hand mixed following these steps.[36]

In addition to testing different methods of mixing concrete aggregates, von Schon's staff tested various aggregate materials which could be used and were available at or near Sault Ste. Marie. The tested mixtures which used local sands, local potsdam sandstone, boulders, and furnace slag from Sudbury, Ontario, as well as a number of local gravels. They also tested a number of commercial grade portland cements, as well as one brand of natural cement and one brand of cement made from furnace slag. The portlands gave excellent results; the slag and natural cements were found to have little strength.

Both the various aggregates and the different brands of cements were formed into 6" x 6" x 24" blocks. At the end of 60 days they were tested for strength. The concrete bar was supported at both ends on blunt-edged iron bars. Between these supports an iron hanger with a wooden platform and weights was suspended from the bar. The weight was increased until the bar broke and the results recorded.[37]

SUPER-STRUCTURE

The tail pit walls and roof were to raise the level of the structure above the surface of the St. Mary's and provide the sub-structure on which the penstocks, generator room and mill rooms were to be constructed.

In the summer of 1898 von Schon was planning to equip the plant with 85 penstock units -- 80 for turbines, 5 as spillways with a discharge capacity equal to that of the power canal (30,000 c.f.s.). The 5 spillway units were reduced to 1 before the power house was constructed, leaving the completed plant with 81 penstocks. Each of the 80 turbine-equipped penstocks was fitted with two discharge tubes with movable gates. These tubes were designed to pass a volume of water equal to that discharged by the turbines when in operation should the latter be shut down. They were also to drain the penstocks of water when they were shut off from the forebay for repairs.[38] (See HAER drawing, sheet 6 of 8)

The penstock construction adopted by von Schon contained several other original features. The partitions between the penstock units or turbine chambers were to be of cellular steel I-beam construction. That is, the skeleton of the wall was to be formed by a number of vertical 12-inch thick I-beams. These divided the wall into sections or cells. These cells were to be filled and the whole wall faced with concrete. According to von Schon this represented probably one of the earliest applications of this type of construction to a hydraulic structure.[39]

For the forward end of the penstock von Schon's assistant, J.W. Rickey, designed a semi-cylindrical steel bulkhead in late 1897. This curved bulkhead was to be built up of double-riveted one-quarter inch thick steel plates (See HAER photos 9 and 10). This was a completely new design and Rickey later patented it.[40] The advantage of this type of construction is indicated by figure 4 on the next page. Basically, Rickey's bulkhead eliminated a considerable amount of masonry work. This resulted in a savings of both money and space.[41] Directly behind the cylindrical steel bulkheads of the penstocks von Schon placed the generator (or pulp grinder) room (See HAER drawing, sheets 4 and 6 of 8). The turbine shafts penetrated the bulkheads through stuffing boxes into this room, where they were to be directly connected to generators (or perhaps pulp grinding machines).

Since power house designs had not been considered by Boller and Bogart in the December 1897 consultation, Alfred Noble was retained in January of 1899 to investigate von Schon's plans for the foundation, sub-structure, and super-structure.[42] Noble made only a few very minor changes in these plans.[43]

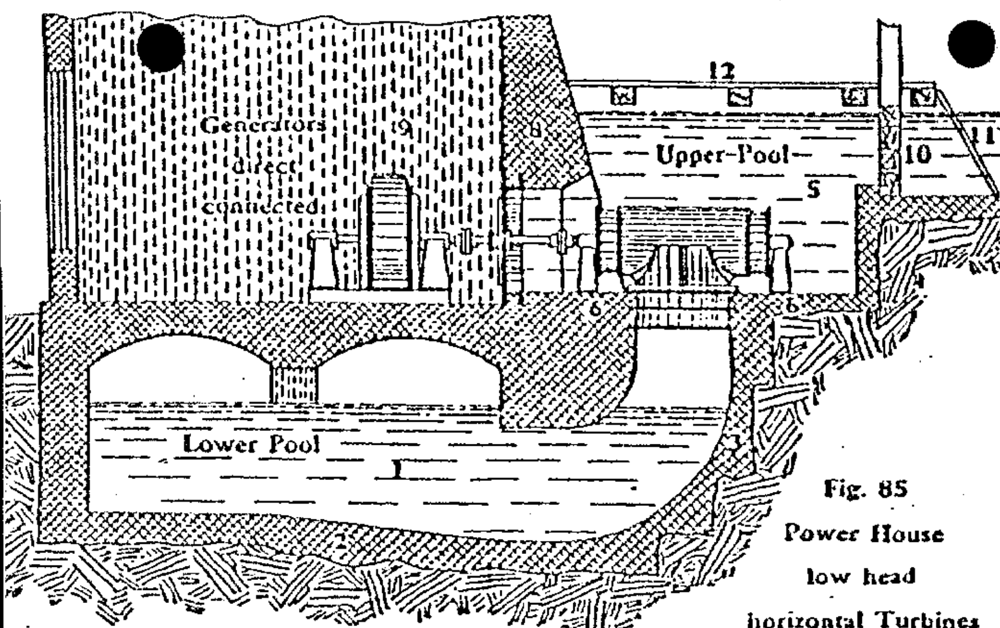
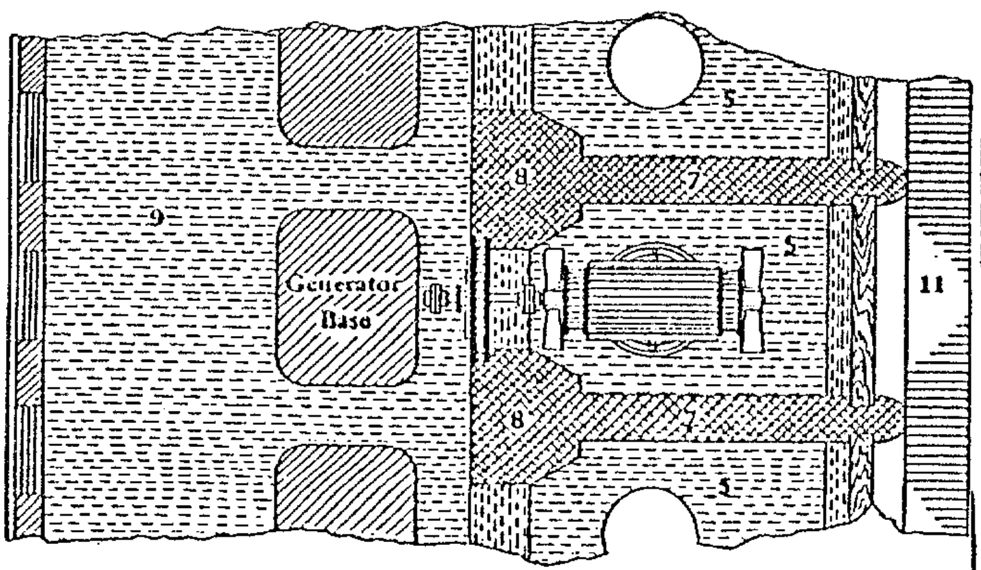
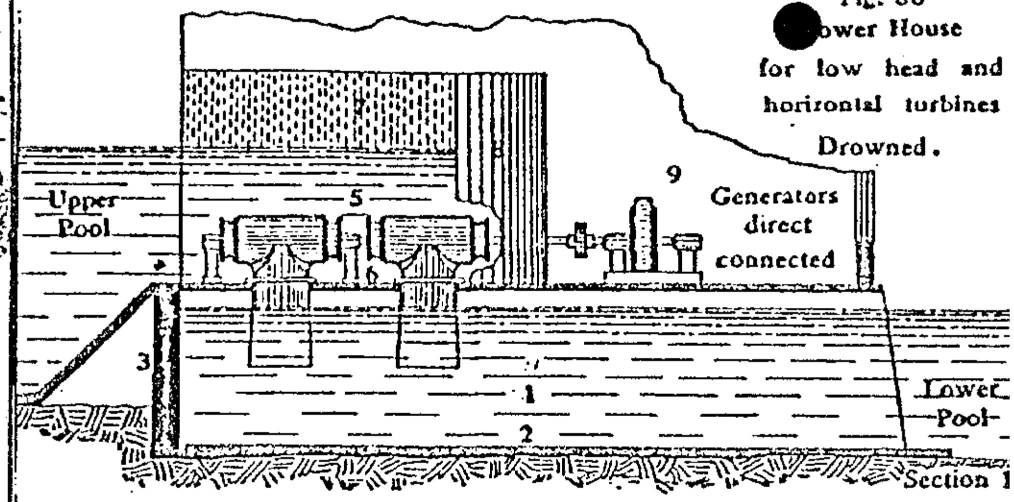


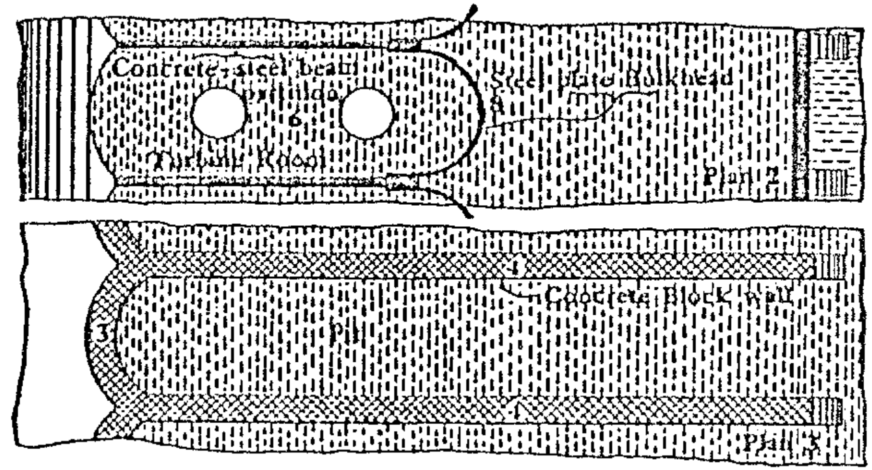
Fig. 85
Power House
low head
horizontal Turbines
drowned in
forebay



H.E.P.161
H.v.S.

Fig. 86
Power House
for low head and
horizontal turbines
Drowned.





Savings in masonry and space through using a steel plate bulkhead. Compare #8 in the figure above (86) with the bulkhead (masonry) labeled 8 in the figure to the left (85). [from von Schon, Hydro-Electric Practice, pp. 261-62]

Figure 17; Advantages of the steel plate bulkhead.

The power canal, turbine installation, and sub-structure as completed in 1902 were substantially the same as conceived in 1898. There were some laterations, but none that completely changed the original concept or general appearance. The same was not true of thepower house super-structure.

By the summer of 1898 the one-story structure originally contemplated by the power company had been altered to a two-story structure, with at least half of the upper story intended for carbide furnaces. The cross section of the power house published in Engineering Record in July 1898 contains a second (Carbide) floor approximately 50 feet wide placed directly over the generator room and only slightly overhanging the penstocks or turbine chambers. (See fig. 5).[44] The castellated Norman architecture of the earlier one-story power house was to be carried out in this new design over both the north and the south elevations (See figs. 5 and 6).[45]

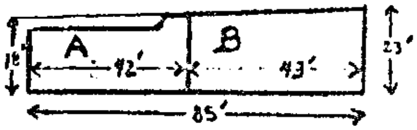
Over the course of the next year these plans underwent several major alterations which are outlined by the chart on the following page. Some of these changes were the result of further consultations between von Schon and Union Carbide engineers. Von Schon had originally planned a second-floor furnace room around 50 foot wide. Union Carbide, however, insisted that they needed a minimum of 75 feet. This resulted in a temporary widening of the entire power house. Since a 125 foot wide foundation had been planned for the structure this was considered no major problem. The power house super-structure was to be increased from 85 to 100 feet in width. The enlarged 75 foot wide Carbide floor was still to be situated mainly over the generator room (widened by 10 to 12 feet), but it also was to project over the turbine bays some 25 feet.[46]

Von Schon at this point believed that he needed at least 18 feet of clear, open space over the penstock chambers so that the turbines could be removed for repairs. In the summer of 1899, however, Albert S. Crane, von Schon's new chief assistant engineer, found that it was not necessary. By raising the bottom of the second (Carbide) floor 2 feet, enough space was left above the top of the penstocks for turbine removal. This discovery led to yet another lateration in power house super-structure plans. The entire second floor was moved south so that the penstock walls projected only 1 foot, instead of 18 feet, out from the main part of the building. At the same time Crane shortened the projected penstocks from around 45 to around 38 feet and reduced the overall width of the building from 100 to 83 feet. The foundation width was reduced from 125 feet to 110 feet. It is substantially in this form that the building was finally constructed.[47]

Table 3: Evolution of the Power House Superstructure, 1897 to 1903

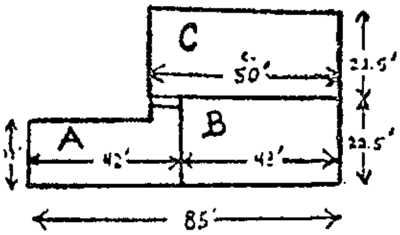
A: Turbine Chambers, Penstocks B: Generator or Pulp Grinder Room
C: Mill or Carbide Floor(s)

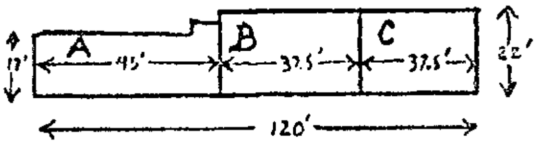
October 1897:



Powerhouse designed for pulp grinders

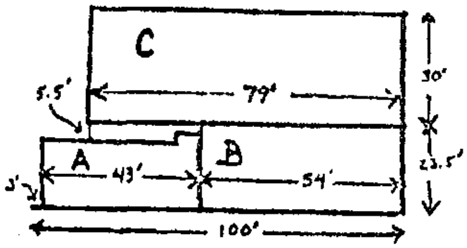
April-May 1898:





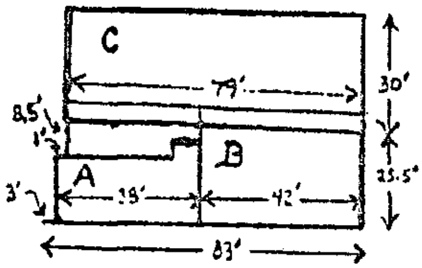
Options initially considered for addition of a carbide furnace room; design on the left selected

December 1898:



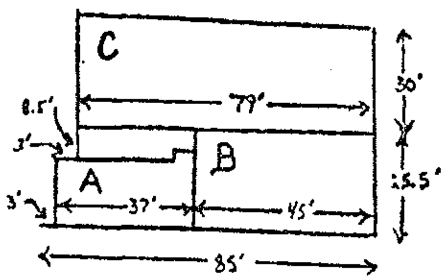
Power house as modified to provide for a carbide furnace room of 75 ft. inside width (79 ft. from outside walls) and 30 ft. clear overhead height

April 1899:



Modification of power house to reduce construction costs. Width reduced 17 ft. by shifting carbide floor almost completely over penstock, but raising the floor several feet to allow sufficient clearance for turbine removal

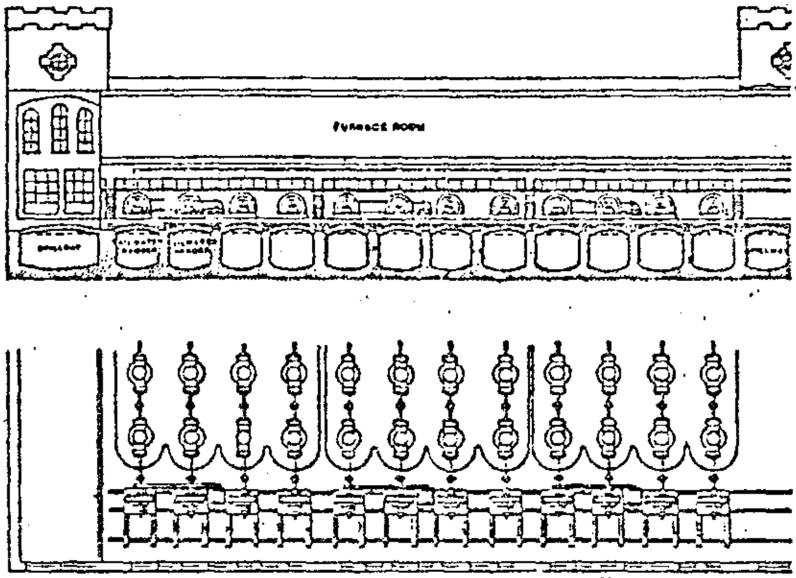
As Constructed:



Power house as constructed

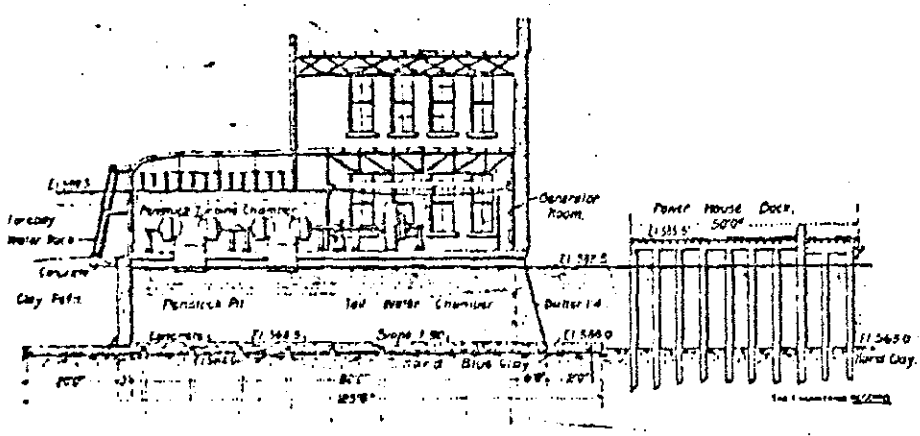
Note: All dimensions in the above drawings are approximate and measured from outside walls

Figure 5: Cross section and plan of the power house as contemplated in mid-1898.



PLAN AND ELEVATION OF THREE SECTIONS OF THE POWER HOUSE.

The Power House in mid-1898 [from Electrical World, v. 32 (1898) p. 131]



Cross Section of the Power House in mid-1898 [from Engineering Record, v. 38 (1898) p. 161]

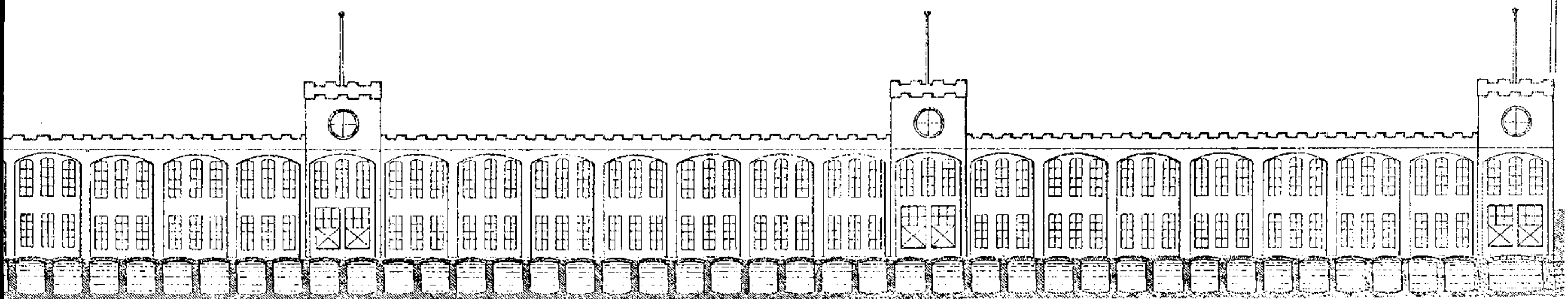


Figure 6: North elevation of the power house as contemplated in mid- 1898.

Other major changes were also made to accommodate Union Carbide in 1898 and 1899. The second story von Schon had contemplated immediately after the contract with Carbide had a ceiling height of around 15 to 20 feet. Further consultation revealed that Union Carbide required at least a 30-foot ceiling, exclusive of roof trusses, because of the overhead conveyors and hoppers used to feed the Horry furnaces.[48] Up until this point, other than the equipment installed, the eastern (Carbide) and western (MLSPC) halves of the building were to be identical. This changed with the raising of the ceiling and roof line to give Union Carbide 30 feet overhead in the eastern portion of the structure. The roof line was raised an equivalent distance on the west, but instead of having one floor with a 30-foot ceiling, the space was divided into two floors, a lower one with a 16-foot ceiling, and an intermediate hollow-tile floor with a 12-foot ceiling.[49] (See HAER drawing, sheets 5 and 6 of 8)

The architecture of the power house, meanwhile, also underwent radical alterations, probably as a result of the other changes being made in super-structure arrangement. J.C. Teague, a local architect, was asked in early 1899 to submit a series of sketches of possible power house elevations. Before making these studies Teague was told that the foundation plan was not to be altered, that the external walls were to be built of red sandstone excavated from the canal, and that each individual unit of machinery was to be provided with a window. He was also instructed not to indulge in costly and extravagent features. He submitted seven architectural studies to Clergue and von Schon in April 1899. These sketches could not be located, but are described in an extant report from Teague to von Schon. Several of the studies were variations on the castellated designs earlier contemplated, one was classed as "Spanish" in type, with decorations omitted, several others were called Romanesque.[50]

Both von Schon and Clergue preferred one of the Romanesque designs, somewhat modified. Von Schon commented that he felt this plan was well suited to the material to be used in construction and would adapt itself to economical roof construction. The architecture, he believed, would have the desired effect of shortening the otherwise tediously long sameness of the building and would give the impression of power, importance, and stability.[51]

The power house facade, as constructed, did manage to achieve these ends. The "tedious" length of the structure is broken up by three large pavillions, one at either end of the structure and one in the center. These tend to draw attention upward and away from the extraordinary length of the building. The pavillion's roofs were equipped with dormers which, no doubt, also helped to break up the horizontal elements of the structure and draw attention upward. The roofs in the two long sections between the pavillions are A-frames. They also counterbalance by their height the lengthy appearance of the power house. Pillasters of various dimensions spaced all along the facade contribute towards breaking up the horizontal elements in the structure and give it the impression of power, stability, and importance. (See HAER drawing, sheet 4 of 8)

The adoption of the pavillions opened up additional overhead space in the center of the building and at the ends. In their half of the structure the power company took advantage of this architectural feature to install small (relatively speaking) fourth floors under the western pavillion and the western portion of the center pavillion. (See HAER drawing, sheet 5 of 8)

There was to be one other major change in the external arrangement of the power house. Original plans called for the roofs over the two long sections of the power house to be identical. Union Carbide, however, insisted that their furnace room required special ventilating facilities to remove the noxious gases (mainly carbon monoxide) and dust given off by the carbide production process. Von Schon hoped that these ventilation needs could be met by the addition of dormers to the roof. But Union Carbide insisted on a ventilator running the full length of their furnace room.[52] Thus the portion of the power house between the western and center pavillions has a conventional A-frame roof, while that between the center and eastern pavillions has a ventilation louvre installed on the top of the A-frame. (See HAER drawing, sheets 4 and 6 of 8)

AUXILLIARY WORKS

While the power canal and power house are the most conspicuous elements in any hydroelectric plant, they are dependent on a large number of auxilliary works. Provision has to be made to close off the penstocks for turbine repairs, to close off the canal, to prevent trash and ice from getting into the turbines. Without penstock gates, headgates, and trash racks even the best designed canal and power house would have limited utility. In addition, at Sault Ste. Marie, remedial works had to be constructed in the rapids before water could be diverted into the power canal at all.

Von Schon originally contemplated equipping each of his 80 to 85 penstock units with a rolling gate and placing in front of each penstock a vertically-situated ice or trash rack.[53] To shut off all the water entering the forebay he planned to install a large head gate, pivoting on a central axle, at the forebay entrance, using the Portage Street bridge as the super-structure for the gate.[54]

All of these elements -- penstock gates, headgates, trash racks -- underwent significant design changes between 1898 and final construction. The need to reduce costs seems to have been the primary factor behind some of the changes. For example, if an ice or trash rack were placed immediately in front of the power house some 1300 feet of iron grill work would have been required. To avoid this expense von Schon by early 1899 had developed an alternative scheme which required much less. He proposed mounting iron grill work on A-frames at a point 200 feet upstream of the power house, just beyond the point where the forebay began to widen. Only 300 feet of grill work were necessary to cover the forebay here.[55] The new ice or trash rack was designed in the shape of a V. At the apex of the "V" a timber ice flume, mounted on timber tresles, led across the forebay to penstock 43, which von Schon used as a general spillway. The flume was used to flush away large chunks of ice, logs, or other debris which had entered the canal and was equipped with gates at both upstream and downstream ends. The rack itself was to be composed of three sets of grillage, a fine mesh was to be placed near the water surface, a course mesh at the bottom of the A-frames, a medium mesh between. These mesh panels were to be raised or lowered in 9 foot sections by a travelling derrick.[56] Contracts for this structure were let in 1901.[57] (See HAER photos 52 and 53)

The roller gates planned for each penstock entrance were eliminated by the decision made in the spring of 1899 to reduce the width of the power house structure by shifting the Carbide or second floor over the penstock chambers. Von Schon replaced them with a travelling derrick mounted on a narrow ledge built where the penstock partitions still projected slightly beyond the facade of the building. This derrick was to be used to lower timber frame sections into gate post recesses set in front of the penstocks. Thus, instead of 80 gates, there would only be 1 travelling derrick and sufficient timber frame sections to close off a half dozen or so gates. These sections could be lifted and transferred to other gates as needed.[58]

Both the design and the location of the headgates (or movable dam) were radically altered after 1898. The decision to move the headgates from Portage Street seems to have been made in the late spring or early summer of 1899.[59] They were moved to the upper portion of the canal. An obvious advantage of the new location was the ability to drain water from the entire power canal, not just the forebay and turbine areas. For a time von Schon contemplated placing the headgates in the rock section. There the company was having to build a railroad bridge across the power canal for the Duluth, South Shore and Atlantic Railroad, and serious thought was given to constructing some type of movable dam or control gates on the same piers as the railroad bridge.[60] Eventually, however, it was decided to construct the gates on separate piers several hundred feet beyond the railroad bridge.

This location was fixed by Clergue's plans for a new bridge across the St. Mary's River. Writing to von Schon on October 27, 1900, Clergue asked him to keep in mind the possibility of connecting the Algoma Central Railway on the Canadian side of the river to the MLSPC's planned terminal railway on the American side by means of a new internationsl railroad bridge. Such a bridge, Clergue pointed out, especially if designed for highway traffic also, would be much more useful, as well as cheaper to construct, if built above the existing international bridge (and thus existing railroad lines). This would place the new bridge's approaches on land already owned by the Clergue enterprises and would mean less inconvenience to the government locks on both sides of the river.[61] This was apparently the reason von Schon moved the headgates west of the existing railroad lines and made plans for a headgate structure that could support both a movable dam and a railroad line.[62] (See HAER drawing, sheet 2 of 8)

The exact form that the movable dam gates were to take remained in doubt for some time after the location had been determined. Noble, who was being used as a consultant for this project as well as the compensating gates, seems to have favored gates of the "stoney sluice" type, i.e., vertical lift gates mounted between stone piers. Von Schon hoped to avoid this type of construction, seeking a cheaper alternative.[63] Clergue, who usually did not intervene too strongly in technical matters and was often on the side of economy, however, pressed in May 1901 for the stoney sluices and secured their adoption.[64] The reason for Clergue's rather exceptional actions in this case may have been the ease with which stoney sluice piers could be adapted to railroad traffic. The design ultimately adopted for the headgates utilized broad masonry piers. The vertical gates used to stop flow into the canal slid up and down in recesses built into the western or upstream edge of these piers. The downstream portions of the pier were connected by a reinforced concrete arch roadway conditioned for either a rialroad or a highway crossing.[65]

The detailed design work on the combination movable dam-roadway was done by Ralph Modjeski, a close friend of Noble. Clergue's policy in retaining consultants seems to have been to use only the best (See Table 4, next page) His choice of Boller and Bogart for guidance in the early stages of the canal design indicated this, as did the use of Noble for consultation on the compensating works and, afterward, many other elements of the development. Modjeski did not represent a break with this policy.

Ralph Modjeski was a Polish immigrant. He first came to America as the advance agent for his mother, Helena Modrzejewski, one of the premiere tragediennes of her time, in 1878. He was himself a pianist of considerable talents, and his parents seem to have intended him to become a

Table 4:

A.S.C.E. Officers involved in the Design, Construction, or Repair of the Michigan Lake Superior Power Company Hydroelectric Plant at Sault Ste. Marie, Michigan,

1895 to 1903

Presidents:

Alfred Noble (1903): Consultant on the compensating works and headgates; general consultant during much of the construction phase of the project, as well as on power house design (he approved the chief engineer's design); consultant on power house repairs (both temporary and permanent. (1897-1905)

Clemens Herschel (1916): Consultant on power house repairs (1904)

Vice Presidents:

Alfred Noble (1900-1): noted above

Clemens Herschel (1915-6): noted above

Alfred Boller (1911-2): General consultant during the planning stages of the project and during the early construction stage; also consultant on power house repairs (both temporary and permanent). (1895-1905)

Samuel Whinery (1892-3): Consultant on power house repairs in 1903 (temporary) and in 1904-5 (permanent). (1903-5)

Gardner Williams (1914-5): Consultant on and supervisor of Holyoke turbine tests conducted by the power company. (1900)

Secretaries:

Alfred Boller (1870-1): noted above

John Bogart (1877-91): General consultant (with Boller) during the early planning phase of the project. (1895-1898)

Treasurers:

John Bogart (1876-7, 1891-4): noted above

Directors:

John Bogart (1873-5): noted above

Alfred Boller (1872): noted above

Alfred Noble (1895): noted above

Samuel Whinery (1891, 1899-1901): noted above

Gardner Williams (1908-10): noted above

Clemens Herschel (1891): noted above

John Kennedy (1898-1900): Consultant on the plans developed by Noble for the compensating works. (1900)

George Y. Wisner (1893-1900): Consultant with Kennedy on the efficacy of the plans developed by Noble for regulating the levels of Lake Superior. (1900)

professional in that field. Modjeski's engineering instincts, however, won out, and he returned to Europe. He graduated in 1885 at the head of his class at the Ecole des ponts et chaussees in Paris. His first engineering engagement was with one of America's premier bridge builders, George Morison. In 1893 Madjeski opened an office of his own in Chicago. By 1900 he had considerable experience and a rising reputation as a bridge designer. He had also befriended Alfred Noble. It was on Noble's recommendation that Modjeski was retained to design the headgates, and he was later retained as the company's inspector of steel work.

After the Michigan Lake Superior project Modjeski went on to enjoy a long and distinguished engineering career, with not only national but international recognition. He was awarded, for example, the Legion of Honor by the French Republic in 1926 and was used as a consultant in 1935 by the Soviet Union on plans for the projected Palace of the Soviets in Moscow. His last major project was the Oakland Bay Bridge.[66]

The headgates designed for the company by Modjeski were, as already noted, of the stoney sluice type. They consisted of four steel shutters or gates about 48 feet wide by 25 feet high, mounted in recesses between 5 masonry piers. Each of the piers was topped by a steel frame tower, on which the gears and shafts that operated the gates were mounted. The gates were connected to sprocket chains which were counter-weighted by heavy boxes of the same width as the gates, so that the gates could be lifted or lowered by a team of 6 to 8 men.[67] (See fig. 7)

Modjeski was asked to begin plans for the structure around June 1901. By the fall he had finished, the sub-structure contract had been awarded, and von Schon was sending out blueprints and specifications for bids on the super-structure. The contract work on this project was divided. The sub-structure was let to H.E. Talbott & Company in October 1901; the super-structure was let to the Dominion Bridge Company of Montreal in late December 1901.[68]

Probably the most important of the auxilliary works and certainly the most novel in conception were the regulatory dams to be constructed in the rapids to maintain the level of Lake Superior. The coming of Union Carbide to the "Soo" and the subsequent alterations made in the power house did not effect these plans. In mid-1898 the company still intended to erect a submerged weir across spans 6, 7, and 8 of the International Bridge.

Noble's assertion that lake levels would be affected by no more than two inches by a structure of this type proved unconvincing. Lake carriers protested that every inch they lost in channel depth cost them thousands of dollars.[69] These protests, as we shall see later, led to a study of the problem by a board of Army Engineers, as well as hearings before the Rivers and Harbors Committee of the U.S. House of Representatives.

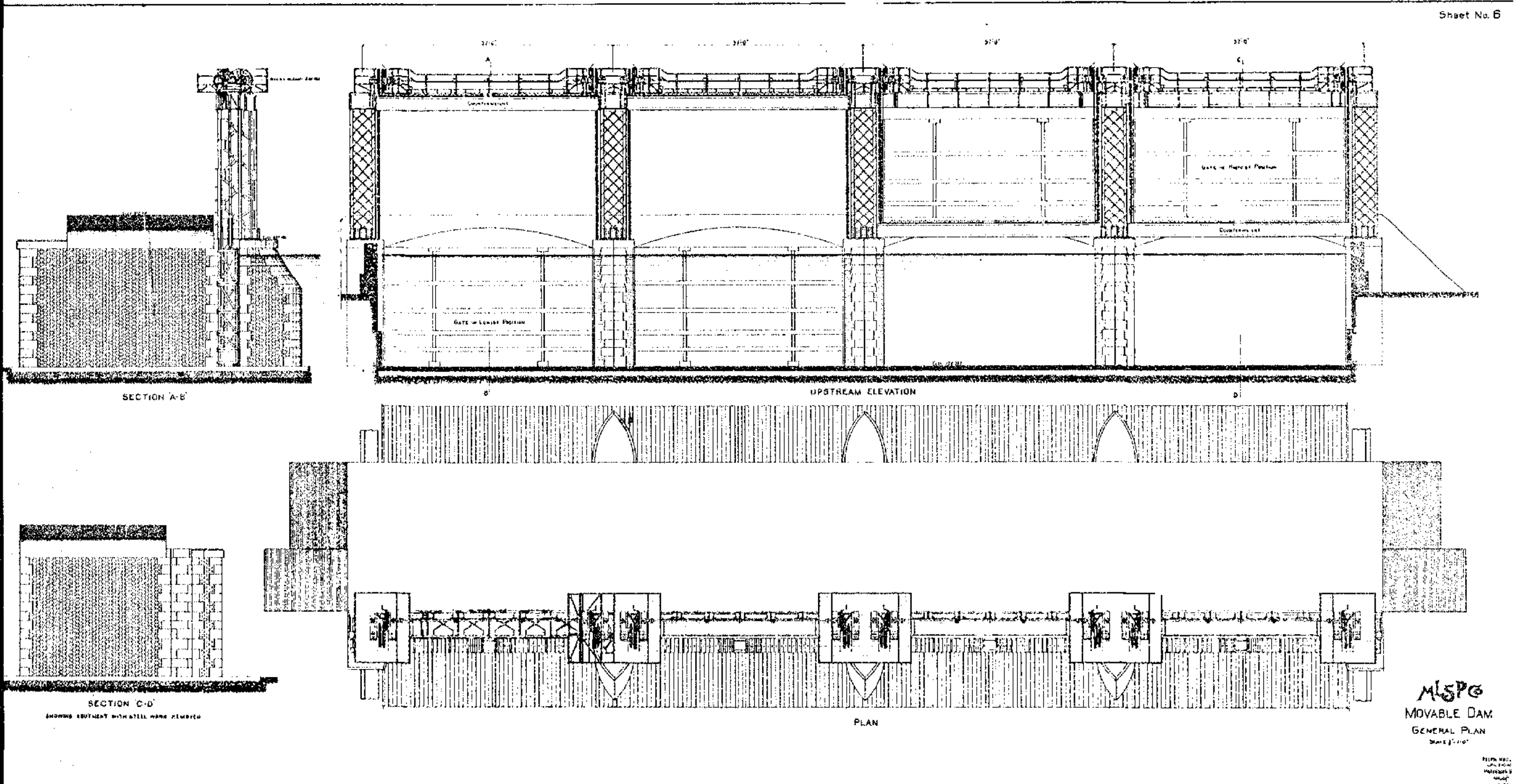


Figure 7: Headgates (or movable dam) designed for the M.L.S.P.C. by Ralph Modjeski, 1901.

MLSPC (page 83)

By 1899 the Corps of Engineers was pushing for works in the rapids that would not only compensate for the water drawn off by the Michigan Lake Superior Power Company, but also allow the lake levels to be regulated between certain fixed, artifical levels.[70] In other words the Corps, which had authority over the nation's navigable waterways, saw in the proposed works an opportunity to regulate the levels of Lake Superior artifically. This, of course, could not be accomplished with fixed structures like wing dams and submerged weirs. Compensating works in the form of sluice gates, similar in form to those planned for the headgates of the canal thus became essential. This was an expense the company had hoped to avoid.

To at least partially satisfy the preferences of the Corps and remove some of the opposition to the entire development, Noble was asked to design a combination works, i.e., partly stoney sluices, partly submerged weirs, with perhaps a temporary wing dam which would allow precision regulation of Lake Superior's levels. At a conference with Corps officers in the summer of 1899 this compromise was found acceptable.[71] To gain additional support for the modified plans and to strengthen their position against those who opposed any water diversion, Clergue hired John Kennedy of Montreal and George Wisner of New York to report on the probable efficacy of Noble's plans in January of 1900. As in the past, the company had again hired men of the highest caliber for the consultation.

John Kennedy (1838-1921), later Sir John Kennedy, was a Canadian engineer. His engineering education had come from the practical school, supplemented by self-study. His first professional engineering engagement had been as assistant engineer in the construction of Montreal's water works. By 1865 he was Assistant City Surveyor of Montreal, then Deputy Surveyor. Between 1871 and 1875 Kennedy had worked as chief engineer of the Great Western Railway, and had designed for them the first double-track line in Canada. As chief engineer of the Montreal Commission from 1875 to 1907 he made that city one of the best ports in the world and Canada's major port of entry. He was a member of virtually every important royal commission dealing with waterways and water power during the latter part of his career.[72]

George Y. Wisner's career was similarly distinguished. An 1865 graduate of the University of Michigan, he was for almost 20 years involved in government surveys of the Great Lakes and the Mississippi River. He went into private practice in 1887, consulting on important river and harbor improvements along the southern coastline. In 1897 he was appointed to the U.S. Deep Waterways Commission and served with that body until 1900. He was, like Kennedy, a distinguished and knowledgable hydraulic engineer.[73]

Kennedy and Wisner approved Noble's plans, feeling that they were perfectly capable of performing as Noble promised.[74]

The location favored by Noble for the proposed mixed works was below the International Bridge, since there they would be at least partially protected from ice during the winter.[75] Some thought was given in 1899 and early 1900 to locating them underneath the International Bridge, using its piers as part of the works.[76] Canadian Pacific, owner of the structure, apparently vetoed this idea.[77] By late 1900 a location above the existing bridge seems to have become the focus of attention, primarily, it seems, because of Clergue's plans for a new international crossing. Besides the advantage the upstream location had of placing most of the approaches on company-held land and avoiding the problem of leading the Algoma Central Railroad's tracks across those of the Canadian Pacific, the calmer water in the upstream location promised easier construction.[78] By December 1900 this decision had been finalized.

The compensating works were to be built 150 feet above spans 7, 8, 9, and 10 of the International Bridge, on the Canadian side of the river.[79] The location of the works on the Canadian side was probably made mainly because the discharge of water was much greater on the north or Canadian end of the river, the highest discharge coming through spans 6 through 9. To block off or control the necessary volume of water would, thus, require works of smaller length on the north end of the river.[80] But there were some other very good reasons for selecting a Canadian over an American location. On the Canadian side of the river Clergue's company held adjacent lands and all riparian rights. On the American side riparian rights in the rapids were claimed by the Chandler-Dunbar Company. If, therefore, there were any dispute with the Chandler-Dunbar Company (and, as we shall see there was) over whether the Michigan Lake Superior Power Company had a right to divert water, the company could always claim they were diverting Canadian rather than American water. A location on the Canadian side also offered less impediment to navigation. (See HAER drawing, sheet 8 of 8)

The final plans called for an embankment to be built above span 10 where the river was slow and shallow. Four gates similar in construction to the "stoney sluices" planned for the canal headgates were to cover the 9th span. A crib dam 240 feet long, and a submerged weir 240 feet long, would follow in that order. The crib dam was to be only temporary and be ultimately replaced with either a submerged weir or stoney sluices. So that only a small part of the channel of the river would be blocked off at any one time, Noble decided to construct these four distinct units one at a time -- first the movable dam, then the submerged weir, followed by the crib dam and the embankment.[81]

Even though the water velocity above the bridge was considerably lower than below the bridge, it was still high -- approaching 10 feet per second. Recognizing that this would make hydraulic construction difficult, company engineers decided to construct a breakwater some 980 feet long above the site. Stone-filled cribs were to be spaced 16 feet apart, the openings between the cribs filled in afterwards. The movable dam and submerged weir sections required river bed excavation. This work was to be done within sand-filled, timber-lined cribs sunk around the sites to form coffer dams.

The foundation work for both movable dam and submerged weirs required the excavation of pier foundations some 6 to 10 feet deep in the river bed, and the sill or apron foundations needed 4 to 7 feet of cutting. After this work was completed and the necessary masonry placed, the aprons or sills were to be placed and the piers built up to completion. The piers for the compensating gates were, apparently at Clergue's desire, designed like those of the headgates to carry a plate girder railroad bridge (never constructed).[82] The super-structure was to be very similar to that used at the canal headgates, even though the dimensions were slightly different. The life gates, for instance, were wide (54 feet 3½ inches), and only about half as high (12 feet 11½ inches). But they, too, were mounted in the grooves of masonry piers and raised and lowered with the aid of counter-weights.

Complete specifications for these structures were prepared by early 1901. H.E. Talbott won the contract for the sub-structure. And, as in the case of the headgates, the Dominion Bridge Company was awarded the contract for the super-structure.

ELECTRICAL INSTALLATION

Much of the early electrical design work at the "Soo" power house was carried out by Union Carbide Company engineers, since the contract with MLSPC required the Carbide company to buy power at the turbine shaft and since Clergue was not yet certain where the remainder of the power was to be sold. Union Carbide took fairly quick action on the electrical plant. The contract with the power company was signed in April 1898. By June 1898 they had placed an order with the Walker Company of Cleveland for half of the equipment they contemplated using at Sault Ste. Marie.

The Walker contract and an 1898 Electrical World article provide most of the extant information on the electrical installation initially planned for the power house.[83] From Walker, Union Carbide ordered 20 alternators and 5 exciters. The alternators were the standard American rotary-field design. They were to operate at 180 r.p.m.'s, delivering 500 h.p. (375 kW) with 93% efficiency. Since plans were to place the carbide furnaces on a floor directly above the generator room, Carbide ordered low voltage machines. The contract specified that the armature would be wound so that either 100 or 200 volts could be delivered to the bus bars. Since Union Carbide had still not irrevocably committed itself to a location within the power house, the contract also contained a provision which would have required Walker to alter the machines to operate a 1000 or 2000 volts at the request of Union Carbide.

The switchboard panels to accompany the alternators were, more or less, standard. They were to be 24 inches wide and contain the usual instruments and switches -- a voltmeter, an amperemeter, synchronizing lamps, 2500 ampere switches and fuses, a recording wattmeter, plus meters, switches, and fuses for the exciters.

The 5 d.c. generators were to be compound wound, self-excited 75 kW (100 h.p.) units, operating at 250 volts with an efficiency of 94%. It was expected that this equipment would occupy about 20 penstock units. Since Union Carbide ultimately expected to occupy 40 units, the Walker Company agreed in the contract to furnish a duplicate set of equipment at the same price, under identical terms, within a three year period if requested. Electrical World noted that the battery of Walker alternators under contract for the "Soo" formed possibly "the largest single order for alternating machinery ever placed".[84]

The Walker alternators were to be arranged in the generator room in groups of 4. Each group of 4 alternators, directly coupled to a turbine shaft, would have a 100 h.p. d.c. generator as its exciter. The exciter was to be placed in the center of the alternator group and driven by belt from a pulley on one of the turbine shafts, but designed so that it could be driven by either of two shafts. Each generator was to have its switchboard placed on a gallery directly above it. The leads from each generator were to be carried from the stationary armature directly up to the switchboard panel. All of the panels were to be connected by massive bus bars (2 by 2½ inches) which would carry the low voltage, high amperage (c. 1800 to 2200 amperes) current upstairs to the Horry rotary furnaces. For each set of 4 generators there were to be 6 Horry furnaces, four in operation at any one time, the other two held in reserve.

The plans for the electrical installation in the non-Carbide portion of the power house were not nearly so well developed in 1898 or, in fact, for a number of years after. Uncertainty as to what other customers might be attracted seems to have been the chief cause of the delay. It was not until early 1902, when the entire development was nearing completion, that any definite decisions were made on MLSPC's electric power plant.

While certain elements of the projected development were not decided upon until late, the basic elements -- power canal and power house location -- were finalized, or apparently finalized, by the summer of 1898. Specifications were, therefore, drawn up for transmission to contractors for bids, with an anticipated completion date of January 1900.

This date was a little too optimistic in view of the magnitude of the development which Clergue, Douglas, and von Schon were planning. In terms of the volume of water the plant was designed to use, it was to be the largest hydropower plant in the world.[85] No previous plant had even approached 30,000 c.f.s. The power house was designed to contain more turbines (320 in 80 penstocks) and more generators (80) than any contemporary hydroelectric plant. And the size of the power house itself was unprecedented. In terms of the designed power output (c. 40,000 h.p.) there was no other hydroelectric plant of greater magnitude, save the recently completed Niagara Falls Power House No. 1. And, as the chart on the following page indicates, even around 1905 the MLSPC works had a design capacity exceeded only by two works located at Niagara.[86] The Niagara Falls units were of a radically different design since they were able to tap a relatively high head -- over 150 feet. Among low head developments at the turn of the century there were none whose output even approached the contemplated plant.[87]

Table 5:
Comparative
Number of capacity on
Floor Dimensions, Capacity, and Generating/of turn-of-the-century direct-connected, horizontal turbine hydroelectric plants (primarily from Adams, p. 102, but some material modified).

Station	Length	Width	No. of Generators	Total KW Capacity
Niagara No. 1*	496	72	10	37,500
SAULT STE. MARIE	1340	80	80**	32,000
Colgate	275	40	7	11,250
Electra	208	40	5	10,000
Canon Ferry	225	50	10	7,500
Red Bridge	141	57	6	4,800
Apple River	140 106	30 22	4	3,000
Santa Ana River	127	36	4	3,000
Great Falls	67.5	55	4	2,000
Garvin's Falls	62 50	30 23	2	1,300
Birchem Bend	56.6	26.7	2	800
Niagara No. 2***	450	70	10	37,500

*used vertical-shaft turbines (as did Niagara No. 2). These were the larges hydroelectric plants in the world at the time.

**planned capacity, rather than number actually installed during the periord 1902-1916. From 1903-1913/4 only about 30 generators were in operation.

***not completed until after the opening of the "Soo" hydroplant

Note: All dimensions are approximate

CHAPTER IV: Footnotes

1. The best summaries of the design plans as finalized in 1898 are "The 'Soo' Water Power," Engineering Record, v. 38 (1898) 161-162; "Water Power Development by the Lake Superior Power Co., at St. Mary's Falls, Mich.," Engineering News, v. 40 (1898) pp. 68-71; also "A review of the general arguments underlying the scope of hydraulic development projected by the Michigan Lake Superior Power Company, at Sault Ste. Marie, Michigan," Reports, B, 146-151.

2. "The 'Soo' Water Power," p. 162; "Water Power Development," p. 69; von Schon, General Report, p. 3.

3. von Schon, General Report, p. 3; Jones to Davis, August 23, 1918 (vf 218-52).

4. As explained in the 1904 General Report von Schon conservatively assumed a 16 foot head. There were not reliable hydraulic formulas available for a canal the magnitude of that contemplated at the "Soo", he explained. Von Schon believed that there was a "strong probability" that the effective head would be above 16 feet, and perhaps might reach 17 or even 18 feet (von Schon, General Report, p. 38). He was correct. The average head at the plant today is between 17 and 18 feet.

5. von Schon, General Report, p. 6.

6. "Water Power Development," p. 69, for the intake wall and warf specifications.

7. "The 'Soo' Water Power," p. 162' "Water Power Development," p. 69.

8. "The Water-Power Plant of the Michigan Lake Superior Power Co., At Sault Ste. Marie," Engineering News, vol. 48 (1902) p. 227.

9. "The 'Soo' Water Power," p. 162; "Water Power Development," p. 69; Construction History Report, MS #2, pp. 1-3 (OCf, von Schon Reports).

10. von Schon, General Report, p. 3; "Review of the General Argument," Reports, B, 147.

11. R.C. Beardsley, Design and Construction of Hydroelectric Plants, New York, 1907, p. 303.

12. "New Water Power Plant at Sault Ste. Marie, Mich.," The Engineer (U.S.A.), v. 39 (1902) 550.

13. "Statement by Michigan Northern Power Company in Regard to Plans for Reconstruction of Power Facilities at Sault Ste. Marie . . .," March 3, 1941, p. 4 (Jf, Box 1).

14. von Schon, General Report, p. 4.

15. von Schon to General Electric, October 15, 1897 (GL 4, 3), for example.

16. Pring, Electric Furnace, p. 105.

17. von Schon, General Report, p. 4.

18. von Schon to Clergue, January 25, 1902 (PL 6, 60-61).

19. Beardsley, Hydroelectric Plants, p. 335.

20. Original inked drawing dated October 15, 1897, numbered 232. Descriptions of the turbine installation at the "Soo" can also be found in von Schon, General Report, p. 18; "The Jolly-McCormick Turbines at the 'Soo'," Iron Age, v. 70 (1902) pp. 1-4; and "The Turbine Equipment at the 'Soo'," Mining Reporter, v. 46 (1902) pp. 445-446.

20a. Rickey to von Schon, October 14, 1897 (Reports, A, 182-85).

21. von Schon to Ashlay B. Towner, December 19, 1896 (GL 1, 255); von Schon to Sickman, January 2, 1897 (GL 1, 314).

22. von Schon to E.A. Fuertes, October 26, 1898 (GL 8, 900-901); von Schon to Rickey, October 3, 1898 (GL 426); "Turbines at the 'Soo'" p. 1.

23. von Schon to T.H. Risdon & Co., September 20, 1898 (GL 7, 348-9), for example.

24. von Schon to E.V. Douglas, November 15, 1898 (GL 8, 228-30); von Schon to E.V. Douglas, November 23, 1898 (GL 8, 296-98); and Reports, B, 152-158.

25. von Schon to E.V. Douglas, March 27, 1899 (PL 1, 152-54.

26. von Schon to Douglas, March 24, 1899 (PL 1, 398); von Schon to Swain Turbine & Manuf. Co., June 27, 1899 (GL 9, 477).

27. von Schon to Clergue, September 15, 1899 (PL 2, 259-64), outlining the plans of Webster, Camp and Lane.

28. Contracts, 271-277.

29. von Schon to Clergue, November 30, 1898 (GL 8, 358-59).

30. "Discussion of stability of 500 h.p. unit Penstock Installation against Sliding," Report by J.W. Rickey for von Schon, October 7, 1897 (Reports, A, 176-81); "The 'Soo' Water Power," p. 162.

31. "The 'Soo' Water Power," p. 162; "New Water Power," p. 550.

32. "Water Power Development," p. 70, gives the specifications for concrete inspection and concrete block construction.

33. Rickey to von Schon, October 16, 1897 (Reports, A, 219-24); von Schon to Clergue, November 30, 1899 (PL 3, 12-14); Tudor to von Schon, January 21, 1899 (Reports, B, 236-239).

34. von Schon to Clergue, November 6, 1897 (GL 3, 459-61).

35. von Schon to E.V. Douglas, January 10, 1898 (GL 4, 454-55).

36. von Schon to Clergue, September 27, 1899 (Reports, 1, 384-91).

37. W.W. Dann to von Schon, April 1, 1899 (Reports, 1, 141-156). W.W. Dann was one of von Schon's assistant engineers. He was the only assistant engineer with von Schon through practically the entire project. See also von Schon's letter published in ASCE, Transactions v. 42 (1899) pp. 135-141, on the cement tests.

38. von Schon, General Report, p. 27. The penstocks had to be able to discharge water when the turbines were not in operation because of War Department regulations (to be discussed later) which required the diversion of a "constant" volume of water from the St. Mary's River.

39. "Sault Power House," Water Power Chronicle, v. 1 (1913) p. 41.

40. von Schon, Hydroelectric Practice, p. 257; Rickey to Davis, November 15, 1906 (vf 222. 7-43); Rickey to von Schon, October 16, 1897 (Reports, A, 201-05).

41. von Schon, Hydroelectric Practice, p. 260.

42. von Schon to E.V. Douglas, January 12, 1899 (GL 8, 691).

43. Noble to von Schon, January 30, 1899 (GL 8, 888-891); also reproduced in von Schon, General Report, pp. 48-51.

44. "The 'Soo' Water Power," p. 161.

45. Soo Democrat, July 21, 1898, has an illustration of the new power house.

46. von Schon to C.H. Hollingsworth, December 30, 1898 (GL 8, 602-03). Hollingsworth was another of the assistant engineers. Also von Schon to E.V. Douglas, April 3, 1899 (PL 1, 172-173).

47. von Schon to E.V. Douglas, April 3, 1899 (PL 1, 172-173); also Reports, 1, pp. 111-118.

48. Blueprint #297 from Union Carbide Company, Chicago, Ill., dated September 6, 1898, in Folder 5, Pocket 3, of Edison Sault Electric Company drawing collection.

49. The reason for this arrangement is indicated in von Schon to Clergue, April 8, 1899 (PL 1, 213). Clergue still had plans for putting in a paper mill. The first floor (generator room) was to have pulp grinders; the second floor (carbide floor) was to have wet machines; and the upper two floors would be available for paper making machinery.

50. J.T. Teague to von Schon, April 3, 1899 (Reports, 1, pp. 119-127).

51. von Schon to E.V. Douglas, April 3, 1899 (PL 1, 206-207).

52. von Schon to E.V. Douglas, April 28, 1899 (PL 1, 267-70); B.F. Price to von Schon, May 3, 1900 (PL 3, 395); von Schon to E.V. Douglas, May 13, 1902 (PL 6, 229).

53. J.W. Rickey to von Schon, October 18, 1897 (Reports, A, 196-200); also the original inked drawing dated October 15, 1897, and numbered 232 in the Edison Sault drawing collection, Folder 5, Pocket 3.

54. "The 'Soo' Water Power," p. 162; "Water Power Development," p. 70; "New Water Power," p. 550; M.G. Barnes to von Schon, April 17, 1897 (Reports, A, 60-68).

55. von Schon to E.V. Douglas, January 19, 1899 (GL 8, 754-56); "Sault Power House," p. 41.

56. von Schon, General Report, p. 26.

57. von Schon to King Bridge Co., January 17, 1901 (GL 14, 404).

58. von Schon to C.P. Nichole, & Bro., March 3, 1902 (GL 18, 507-09); see also von Schon to Capt. P.F. Thrall, October 2, 1901 (GL 17, 88).

59. C.H. Hollingsworth to von Schon, June 1, 1899 (Reports, 1, 223-24).

60. Construction History Report, MS #1, p. 3 (OCf, von Schon Reports).

61. Clergue to von Schon, October 27, 1900 (VP, 29-30).

62. Clergue to von Schon, November 14, 1900 (VP, 61).

63. von Schon to Noble, October 4, 1900 (GL 13, 463-64); von Schon to Noble, January 22, 1901 (GL 14, 433); von Schon to Noble, February 1, 1901 (GL 15, 6).

64. von Schon to Noble, May 24, 1901 (GL 15, 473).

65. von Schon, General Report, pp. 25-25a.

66. "Memoir of Ralph Modjeski," ASCE, Transactions, v. 106 (1941) pp. 1624-28.

67. von Schon, General Report, pp. 25-25a; Original Inked Drawing, #1226, dated November 6, 1901, Folder 2, Pocket 1, Edison Sault Electric Company drawing collection.

68. Construction History Report, MS #1, p. 4; Contracts, 297-303 and 218-225.

69. For examples of the lake carriers' concern over lake levels and the proposed diversion see: "Between Wind and Water," Marine Record, v. 23 (March 7, 1901) p. 10; "To Maintain Lake Levels," ibid. (April 5, 1900) p. 5; "Power Canal at Sault Ste. Marie . . .," ibid. (April 12, 1900) pp. 5, 8.

70. Noble to von Schon, June 6, 1899 (PL 1, 475-78).

71. von Schon to Clergue, August 19, 1899 (PL 2, 175).

72. "Memoir of Sir John Kennedy," ASCE, Transactions, v. 85 (1922) pp. 1695-97; also "Kennedy, Sir John" in Charles Roberts and Arthur L. Tunnell, A Standard Dictionary of Canadian Biography, v. 1, Toronto, 1934, pp. 287-88.

73. "George Y. Wisner," Who's Who in America (edition unknown, an offprint). p. 1977.

74. von Schon to Clergue, March 5, 1900 (PL 3, 252-54).

75. von Schon to Clergue, October 12, 1900 (PL 4, 196-97).

76. von Schon to Clergue, January 17, 1900 (PL 3, 156-57).

77. von Schon to Clergue, August 31, 1900 (PL 4, 109).

78. Clergue to von Schon, October 27, 1900 (VP, 29-30). See also Clergue to von Schon, December 7, 1900 (VP, 89); Clergue to von Schon, January 6, 1902 (VP, 306-07); Clergue to Shaw, Waite, Cady & Oakes, January 6, 1902 (VP, 308-10).

79. Clergue to von Schon, November 14, 1900 (VP, 61).

80. von Schon, General Report, p. 30.

81. G.F. Stickney, "The Compensating Works of the Lake Superior Power Company," ASCE, Transactions, v. 54 (1905) pp. 348-353.

82. von Schon, General Report, p. 29.

83. "The New Plant of the Union Carbide Company at Sault Ste. Marie, Mich.," Electrical World, v. 32 (1898) pp. 131-33; Contracts, 19-36.

84. "New Plant of Union Carbide," p. 132.

85. Joseph P. Frizell, Water-Power, 3rd ed., New York, 1910, p. 509.

86. "Electrical Development at the 'Soo'," Electrical World and Engineer, v. 40 (1902) p. 770.

87. Beardsley, Hydroelectric Plants, p. 314.

CHAPTER V:

CONSTRUCTING THE HYDRO (1898-1902)

In April 1898 the power company invited tenders for the construction of the power canal, the power house, and the intake. Bids on these basic contracts were opened on July 1, 1898. No contract, however, was finalized for several months. This delay, an omen of things to come, was probably due to several factors. The redesign work necessary to accommodate Union Carbide was one;[1] another was the renewal of the ordinance regulating affairs between the power company and the city.[2]

The contract for dredging the upper intake section was awarded to H.W. Hubbell & Company of West Bay City, Michigan, a well-known dredging and hydraulic construction firm in the Great Lakes area.[3] E.O. Smith Co. of Philadelphia was awarded to contract for excavating and constructing the power canal proper and the lower segment of the intake.[4] E.O. Smith was a nationally-known firm with wide construction experience. They had been involved in the construction of the first Niagara Falls hydroelectric plant and the Chicago Drainage Canal a fews years earlier. The contract for excavating and constructing the forebay and the power house was awarded to Mason & Hodge of Frankfort, Kentucky.[5]

It was anticipated on the day the contracts were opened (July 1, 1898) that the plant would be completed by January 1, 1900.[6] This date had to be steadily moved backward as construction got under way and things began to go wrong. By early 1899 completion was expected no sooner than the summer of 1900.[7] By February of 1900 it was November 1, 1900.[8] By April 1900 the project was expected to be completed only in 1901.[9] By early 1901 it was clear that the power development would not be opened until the following year.[10] In fact, it was not until the fall of 1902, fully two and a half years behind the original schedule, that the hydroelectric plant was opened.

Almost from the first construction fell behind schedule. Because of the delays in awarding the contracts, none of the contractors were able to assemble their plant and begin construction before September. Mason and Hodge did start excavation at the projected power house site on the first of that month, but it was not until towards the end of the month that E.O. Smith began excavation on the rock section of the canal and not until the following months did work begin on Sections II (October 10) and III (November 26). H.W. Hubbell began dredging in the intake on November 2, 1898.[11]

A comprehensive description of the construction of the Michigan Lake Superior Power Company hydroelectric plant is difficult because so many different operations were going on simultaneously. For instance, at one point in 1901 different crews were working simultaneously

Table 6:

Some of the Contractors on the Michigan Lake Superior Power Company Hydroplant

1. E.D. Smith Co., Philadelphia	Excavation of the rock, earth, and lower intake sections of the canal; canal lining in timber section; construction of intake coffer dams
2. Mason & Hodge, Frankfort, Kty.	Excavation and embankment work in the forebay; construction of power house coffer dam; excavation and construction of power house foundations; construction of power house sub- and super-structures
3. H.W. Hubbell & Co., West Bay City, Michigan	Dredging of intake area and construction of retaining cribs for walls in that area
4. T.H. Riddle & Co., New Brunswick, New Jersey	Pile driving for coffer dam at power house and for power house foundations under sub-contract from Mason & Hodge; concrete block construction; pile driving for bridge abutments
5. H. E. Talbot & Co., Dayton, Ohio	Sub-structure of headgates and compensating gates; breakwater for compensating gate construction
6. Frankman Brothers & Morris, St. Paul, Minn.	Timber bulkhead work along the canal; maintenance of temporary bridges and water mains crossing the canal; forebay trash rack foundation; bridge abutments
7. Dominion Bridge Company, Montreal	Steelwork on headgates and compensating gates
8. Charles Brown, West Superior, Wisconsin	Construction of machine shop and masonry work along canal bank
9. American Bridge Company, New York	Erection of steel work in power house
10. Russell Wheel and Foundry Co., Detroit	Trash rack in forebay; stairs in power house; cast iron column bases
11. Garry Iron & Steel Co., Cleveland	Power house roof

on intake cribs, rock excavation, lower intake excavation, earth section excavation, pile driving in the earth section, timber lining in the earth section, forebay excavation, forebay embankment lining, power house substructure construction, power house super-structure construction, compensating works construction, headgate construction, and turbine installation. The chart on the following page attempts to lend some order to this confusion. The text of this chapter reviews the construction of each of the different elements in the total power plant separately.

THE UPPER INTAKE

Of the three major contracts, the smallest was the Hubbell contract for work on the upper intake. Von Schon's plans called for a tapering channel 20 feet deep to be dredged from the upper intake coffer dam to the shipping channel. Some dredging had been done in this general area as early as 1896 by another company when the project was in its planning stages. But the extensive early alterations made in the canal plans had led Clergue to discontinue this work on December 12, 1896.[12]

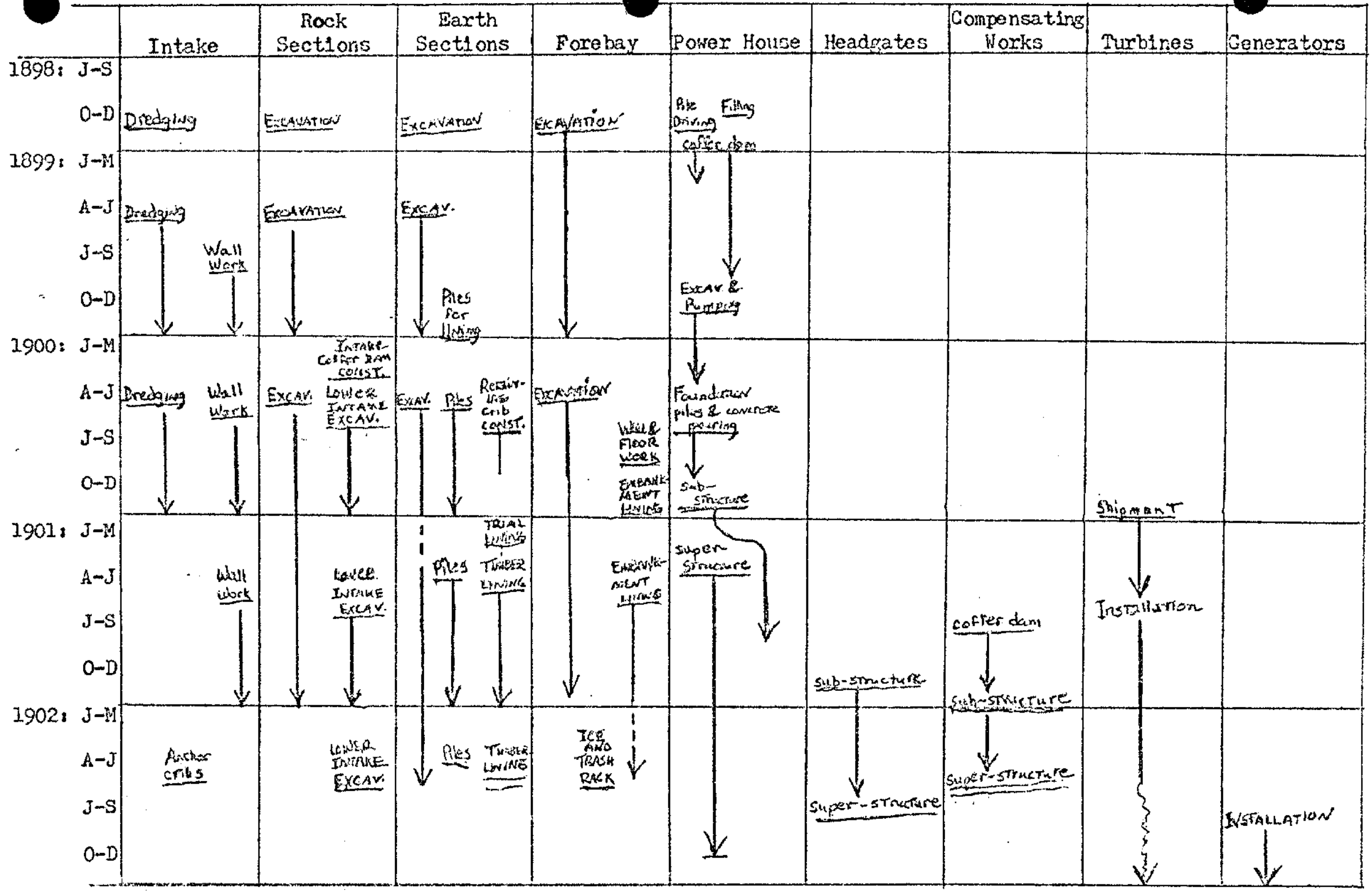
Hubbell's dredges began work in the intake in November 1898. They continued to work through the remainder of the year and on into January 1899 before laying up for the winter. Resuming work in May, Hubbell by the fall of 1899 had almost dredged the channel to required depth all the way to the shipping channel, and in November he reached the channel. Meanwhile Hubbell work crews had begun to construct the retaining cribs and bulkheads which were to form the sides of the intake canal. Work here, however, was often held up by difficulties in securing timber, a problem that was to plague not only Hubbell, but some of the other contractors.

Hubbell and his work force again laid up through the winter of 1899 and 1900, resuming dredging in April. As in the previous year most of the dredged material was loaded on scows and transported across the river to dumping grounds on the Canadian side. Occasionally, however, the dredged material was simply cast over to form embankments projecting out into Ashmun Bay both north and south of the projected retaining walls. Tracks were built on these embankments, and box cars brought loads of material excavated from the canal and dumped them.

Most of the dredge work carried out by Hubbell in 1900 involved finishing up and leveling off the bottom of the channel dredged the previous year. This work was directed by von Schon's assistant engineers who had sounded the area during the winter months. Most of Hubbell's work crews were engaged in constructing the timber retaining cribs for the canal walls. Some of these were completed, filled with ballast, and sunk in position before the year was out. (See HAER photo 11) Work was discontinued for the winter again in December 1900.

Table 7

Construction Progress Chart: Michigan Lake Superior Power Company Hydroelectric Plant, 1898-1902



Note: all dates are approximate

In the spring and summer of 19D1 Hubbell resumed sinking retaining cribs on the sides of the intake channel and finished placing the intake bulkhead warf.[13] By mid-summer Hubbell crews were building the sloping embankment walls behind the cribs and paving their slopes with stone. By November 1901 Hubbell had largely completed his contract. The intake section above the coffer dam was finished. The last remaining work was the construction and placement of 2 anchor cribs for an intake boom, designed to keep floating matter out of the canal. These were put into place in the early spring of 1902.

Of all the work involved in constructing the canal, that in the upper intake section was probably the most routine. There were no important incidents or accidents. The only major delay was due to early trouble with the Canadian government over the dumping grounds being used on that side of the river, and this difference was settled by early 1899. Von Schon had only minor critism of Hubbell's contract performance. He noted that some time was lost by dredges waiting for scows, something which could have been avoided by providing more scows. Delays in crib construction, he also complained, had often forced the dredges to have to reprepare crib sites. But, on the whole, von Schon regarded the upper intake section work as being done in a "very satisfactory manner", and "Properly and as expeditiously as possible".[14]

While Hubbell had not managed to complete his work by April 1900, as provided in the contract with the power company, he had substantially finished it a full year before the plant was officially opened (October 1902). He had also avoided any major disputes with the chief engineer. The same things can not be said of any other major contractor on the project.

THE CANAL FROM LOWER INTAKE TO FOREBAY

The contract for both excavating and lining the canal from the upper intake coffer dam to the forebay was led to the E.D. Smith Company. The general plan fo work contemplated was excavating a canal 22 feet deep and 200 feet wide from the upper intake coffer dam through a rock section using a roughly rectangular canal prism. When the canal began to pass through sand, gravel, or clay, the prism was to be altered to a trapezoidal shape. The depth would be increased to 23 feet, the width at the water surface increased as well. The bed and sides through this section was to be timber lined.[15]

Work on the rock section began first. E.D. Smith installed his plant in late August and early September of 1898, laying service track as well. Channeling machines were first moved into the canal right-of-way. These machines blocked out sections of the rock. (See HAER photo 12) They were followed by drill crews, with pneumatic drills. They drilled holes in the rock for the blasters. (See HAER photo 13) The blasters filled the holes with gunpowder and touched the charges off. After the rock had been blasted it was picked up by steam shovel or locomotive crane and loaded into dump cars which ran along specially-laid temporary track. The dump cars, pulled by locomotives, were hauled to a dump area, where the cars were unloaded and returned to the cut for refilling. (See HAER photos 14 through 16) After the first cut was completed, and the channel excavated to a depth of 4 to 6 feet, a second cut was made by the channeling machines, with drilling, blasting, loading, dumping, and reloading following once again at the new level.

In the earth sections of the canal, the operating methods were slightly different. Here, for the most part, blasting was unnecessary. Most of the excavation was done by steam shovel and steam derrick. Removal of the material, however, involved the same combination of temporary track, dump cars, and locomotives as in the rock section.[16] (See HAER photos 17 and 18)

Excavated material was removed to several locations. Rock from the lower intake and the rock section was, in part, used to provide stone for making concrete for the power house. Some of the stone was hauled across the river by Algoma Central Railroad engines for use on the Clergue projects under construction in "Soo", Ontario. Some of the rock was saved for the exterior walls of the power house. Much of the material, however, was used to fill in Ashmun Bay along both sides of the intake channel. As noted, embankments were constructed out into the bay, track laid on the embankments, and the loaded cars run out onto the embankments and dumped. Other dumps were located along the old canal right-of-way, and alongside the projected forebay and power house locations. Excavated material from the canal was also used to construct the coffer dams at the intake and behind the power house.

The removal of excavated material to the dump sites was one of the most frequent sources of strife between the E.D. Smith Company and von Schon. Until March 1900, under the terms of the contract, the E.D. Smith Company was to handle the disposal of excavated material, hauling it to locations designated by the power company. As construction fell further and further behind schedule, von Schon began to complain that Smith had not placed enough dump cars and locomotives in service. The steam shovels and the locomotive and steam derricks, he asserted, often had to suspend work and wait for the return of a dump train. He also complained about poor organization of dump train traffic and inefficient dumping procedures.[17] To remove this source of friction, the power company and E.D. Smith reached a new agreement in early 1900 under which E.D. Smith would place the excavated material on the banks of the canal in dump cars. Removal from that point and dumping would be handled by crews responsible directly to the power company.[18] This did not eliminate the problem. There were still complaints that the shovels and cranes overbalanced the dump cars and that the dump trains were delivered to the canal banks in small lots.[19] But the new arrangement did go far toward eliminating a major trouble spot in power company-contractor relations.

Another source of friction, particularly during the early stages of excavation was the size of the E.D. Smith Company plant. During 1898 and early 1899 E.D. Smith had only two or three steam shovels, four locomotives and less than a hundred dump cars in the "Soo". Von Schon's calculations indicated that with this plant there was no way construction could be finished on schedule.[20] He thus pressured the E.D. Smith Company to increase the size of their plant, at one point urging Douglas, a Philadelphian, to use his connections with the contractors, a Philadelphia firm, to bring in more equipment.[21] As construction progressed E.D. Smith did steadily increase their plant. In 1899, for example, three more steam shovels were added, along with some additional dump cars. The total plant they eventually used consisted of 7 steam shovels, 2 locomotive cranes, 9 steam derricks, 6 channeling machines, 9 steam or compressed air drills, 6 steam or compressed air pumps, 12 locomotives, and 258 six-yard dump cars, along with a machine ship tp keep this material in repair, and a compressed air and steam generation plant.[22] Of course not all of this material, due to breakdowns, was ever in operation at any one time. In addition to this plant the company had about 7 locomotives for hauling the trains of dump cars away from the canal bank. Von Schon was never completely satisfied with the size of the Smith Company plant,[23] but the additions they made after 1899 did represent a substantial increase over initial conditions.

Dumping and plant size were but two sources of friction between E.D. Smith and von Schon. Von Schon also did not approve of the type of equipment used by Smith. The soil in the sand and clay sections of the canal was naturally rather soft. What von Schon felt was needed there was a large plant made up of small units -- small steam shovels, small cranes, light narrow guage rails, small locomotives and dump cars. Instead the Smith plant in the earth section was substantially the same type as that used in the rock section where heavy equipment was appropriate.[24]

They were also methodlogical disagreements. Von Schon's specifications had called for a very methodical excavation of the earth section, beginning at the lower end of the canal and carried upwards toward the intake, with the timber lining added as successive cuts were made to prevent the canal banks from caving in. The program was designed to insure that water would drain from the canal excavation into the forebay where it could easily and conveniently be pumped out into the river.[25] Instead of adopting von Schon's very methodical excavation procedures, the E.D. Smith company worked in a very haphazard fashion, making seemingly random cuts in every direction and completely ignoring the threat of cave ins.

The results of this policy were catastrophic at times. On June 6, 1899, for example, a major rain storm caused large cave ins at several points along the canal line, flooded the partially-excavated channel, and put several steam shovels out of action for over a week.[26] In December 1899 another rainstorm filled the rock cut to a depth of 16 feet, nearly submerging two steam shovels and delaying work for 10 days.[27] (See HAER photo 19) In July 1900 another storm caused a major cave in near Spruce street; a large section of piling was carried away and a steam shovel overturned.[28] (See HAER photo 20) The mushy soil conditions in the canal cut created by E.D. Smith's excavation procedures led to continual problems with bank slides. The service tracks shifted under the weight of the dump trains, as well as, causing locomotives, cars, and cranes to derail or overturn. Von Schon and his staff were not the only ones dismayed by this performance. Boller, after touring the construction site, commented that the earth section had been "gnawed" all over "in a disjointed sort of way", without methodical excavation.[29]

The construction delays were not, however, completely the fault of the E.D. Smith Company. The temporary interceptor sewers which the company constructed to keep rain water from draining into the canal failed on several occasions.[30] And the MLSPC dump grounds were inadequate. The designated dumps for parts of Section II and III were in the old canal bed, which was located over the muck formation. The tracks in these areas tended to sink whenever a load was brought in, causing derailments and time lost in replacing and relocating the track.[31,32]

After getting off to a slow start in the fall of 1898 and the spring of 1899 excavation of the canal channel never caught up with schedule. By the fall of 1899 it was clear that the canal would not be completed anywhere near April of 1900. Only 1/3 of the necessary material had been removed from the rock section, only 1/4 from the earth sections. Excavation in the lower intake area had not even begun. Von Schon forecast that with the operating plant excavation could not possibly be finished before the fall of 1901, with the timber lining work running, necessarily, a month or two behind that.[33] Even this was an optimistic prediction.

Excavation in the rock section began, as noted, during the fall of 1898. It was suspended for the winter and resumed in the spring of 1899, already running far behind schedule despite day and night work. Excavation was suspended again in January and February of 1900. Work resumed in the spring of 1900 and was carried on continuously in the rock cut until December of 1901, when the job was practically completed except for touch-up work. Where the rock sides were rotten or damaged, or where the rock fell below the level of the canal bank company masons erected masonry walls or smoothed the sides with Portland cement. This touch up work began in 1899 and continued through much of 1902. (See HAER photos 21 through 25)

Excavation in the earth sections was also suspended for the winter of 1898-1899. It, too, resumed in the spring of 1899. From that point it was carried on continuously, day and night, summer and winter, until the canal was completed in June 1902. (See HAER photo 26)

In the lower intake section the E.D. Smith Company was very tardy in beginning construction. Under the terms of the contract between MLSPC and E.D. Smith, the latter was to begin work on this section within 30 days of being instructed by the chief engineer. Von Schon issued such orders in May 1899. His orders were completely ignored until October, when a small crew was moved to the site and some preliminary dredge work began.[34] The upper intake coffer dam, the structure absolutely necessary to beginning dry excavation in the area, was not completed until March 1900. The lower intake coffer dam was not built until after that, and dry excavation did not begin until May.

E.D. Smith Company crews and equipment worked in the lower intake area through the remainder of 1900. (See HAER photo 27) Work was suspended during the first 4 months of 1901 because of the cold weather. It was resumed on April 27 and again continued through the spring, summer, and fall. By the end of the year most of the excavation work had been completed and company crews were at work on timber crib construction for the retaining walls. (See HAER photos 28 and 29) Work slowed to a snail's pace through January, February, and March of 1902, but both excavation and wall construction were completed by April or May. (See HAER photo 30) The lower intake coffer dam (i.e., the coffer dam between the lower intake and the rock section) was removed in the summer. The upper intake coffer dam was to remain in place until late 1902 or early 1903 because the headgates were not yet operative.

The work which the E.D. Smith Company delayed the longest on was the revetment, or timber lining, in the earth sections. Because the contractor was doing so little to protect the canal banks in the earth sections from erosion and slides, von Schon had his employees place stone rip-rap on some of the exposed banks in 1899 and 1900. Pile-driving for the timber lining did not begin until the fall of 1899, and after being suspended for the winter, was resumed in the spring of 1900. (See HAER photos 31 and 32) This provided some reinforcement for the canal banks, but piles alone were insufficient. Slides continued to plague construction. (See HAER photo 33) Timber lining did not begin until the winter of 1901, when the power company laid down a trial

Table 8:

PROGRESS OF EXCAVATION, E.D. SMITH COMPANY, 1898-1902 (in yd.^{3})

Year	Dry Intake Sec.		Canal Sec. I.		Section II & III	
	Rock	Earth	Rock	Earth	Rock	Earth
1898	--	--	29,300	9,230	--	60,623
1899	--	--	169,692	41,061	1,041	479,668
1900	150,125	8,856	176,769	14,792	22,708	621,143
1901	38,908	48,144	141,847	2,011	50,026	175,581
1902	7,387	13,485	9,542	4,504	--	61,755
	196,420	70,485	527,150	71,589	73,775	1,398,770

section in the clay portion of the canal. (See HAER photo 34) Timbering was not taken up by the contractor until the spring of 1901. Once begun, however, it continued at a fast pace until the following winter, when work had to be suspended because the clay puddle needed between the sills for leak protection, could not be mixed and placed in freezing weather. Lining work was resumed in the spring of 1902 and completed during the summer.[35] (See HAER photos 35-37)

During the course of construction few design changes were made in the area of the intake or in the rock section. The canal as completed was substantially the same as the canal designed. This was not the case, however, in the earth section, where several major changes were made during the course of construction.

As originally planned, the earth section was to be covered with a timber lining shaped like a trapezoid. This lining was to be laid on 12" x 12" timber sills placed on top of wooden piles driven down in rows 5 feet apart. Apparently for economy reasons, the spacing of the timber piles was latered. The pile rows were retained at 5 foot intervals on the side of the canal channel, but increased to 7.5 feet on the bottom.[36]

The other major change occurred in the clay section (Section III) of the canal. In 1900 two major land slides in this section led von Schon to suspect that the banks of the canal prism in that section were too steep.[37] At Noble's suggestion Thomas Monro was called in to consult with von Schon on the problem. They replaced the planned trapezoidal canal prism in the clay section with a semi-eliptical prism.[38] This modification replaced the single slope of the trapezoid with three less steep slopes. The depth of the canal, as well as its width, were increased slightly in this area to maintain a uniform cross-sectional area. (See HAER Drawing, sheet 3 of 8)

There was a minor change, also, in the construction of the berm, the portion of the canal bank above the timber lining. Originally von Schon had planned to lay two 12" x 12"s side by side at the top of the timber lining and form a paved clay slope behind. He substituted for this construction three 12" x 12"s placed on top of each other, with the clay embankment and the paved slope formed behind them.[38a]

Beyond these changes the construction of the timber lining proceeded more or less according to original plans. Piles were first drives across the canal prism from the top of one bank to the top of the other. Sills were laid on the piles, and deck planking added as soon as the clay puddling had been placed between the sills. Hemlock planking 2 inches thick was laid on the bottom of the canal (and on the lower slope in Section III); 3-inch planking was laid on the slope. (See HAER photos 38 and 39)

FOREBAY AND POWER HOUSE

Mason and Hodge had the contract for power house and forebay excavation and construction. Even though their work, like E.D. Smith's, ran constantly behind schedule, relations between the power company and Mason and Hodge were usually on a more friendly plane.

The forebay work involved excavating and leveling the area in front of the power house to 575 feet above sea level, forming the forebay embankments, and constructing a timber apron from the forebay floor to the penstock floor at 585.5 feet above sea level. Compared to the amount of dirt work carried out by the E.D. Smith Company on the canal route proper, this was a relatively small-scale project. Much of the early work was carried out entirely by hand, using laborers with pick and shovel to dig and load the dirt into horse-drawn carts. Later a scraper was brought in, and at one point some steam shovel work was done, but the bulk of the material was hand excavated. (See HAER photo 40)

Excavating work began on the forebay in September of 1898 and continued through the fall of 1899. Operations were terminated around January 1900 as the work force was moved to power house foundation excavation. Forebay work was resumed in the spring of 1900 and carried to completion in late 1901. Piles were driven and the forebay embankments lined between late 1900 and early 1902. (See HAER photo 41)

There was one very important change made in von Schon's plans during forebay construction. Original intentions were to plank over the forebay floor in a manner similar to the earth sections of the canal. Apparently for economy reasons, this plan was abandoned.[39] The forebay was planked only up to the ice and trash rack. (See HAER photos 42, 43, also 41 and 60) A timber apron, supported on piles, was run up at an incline from the forebay floor to the turbine chambers and clay fill packed beneath it. But the remainder of the forebay was left uncovered. It was hoped, unfortunately in vain, that the natural clay bed which formed most of the forebay floor would be impervious to water and prevent leakage underneath the power house foundations.

Essential both to the completion of the forebay work and to the preparation of the power house foundations was a coffer dam. Von Schon had located the power house near the dock line in the St. Mary's River. Original plans were to construct a very large (2,000 ft long) coffer dam around this area, pump the water out, and excavate the area dry. Mason and Hodge, however, requested permission to excavate the power house site with dredges while the coffer dam was under construction.[40] This work began on September 2, 1898, and continued to

November 23. The dredging revealed that the clay formation on which the power house foundation was to lie was not as regular as anticipated. In between the points where test borings had been made in 1897 the dredges found pockets and gulleys filled with silt as much as 6 to 13 feet below anticipated foundation level. The dredging also indicated that the clay bed sloped from east to west, and that it was considerably below the anticipated foundation level on the west end. These discoveries forced von Schon to move the planned power house site 100 feet southward.[41] Mason and Hodge began dredging in the new area on November 23 and completed dredging operations on December 26, 1898. (See HAER photo 44)

At the same time that Mason and Hodge dredges were excavating the prospective power house site, their pile drivers were driving the first piles for the coffer dam. (See HAER photo 45) Von Schon's specifications called for the erection of two rows of triple-lap sheet piling spaced 15 feet apart. Pile driving continued through the winter and was completed on April 6, 1899, considerably behind schedule. (See HAER photo 46) As in the construction work at the intake, difficulty in securing good timber was partially to blame.[42]

The space between the piles was to be filled with material removed from the forebay. This material was to be deposited on either side of the coffer dam as well, to better seal the dam, and to prevent the walls from bulging outward. Filling was expected to closely follow the pile drivers as they worked their way across the site from both sides. The excavation and dumping equipment installed by Mason and Hodge, however, was simply not heavy enough to keep up with the pile drivers, so filling also fell behind schedule. Other factors contributed to the tardiness of filling. Von Schon had intended to use the material excavated by the dredges as coffer dam fill, but this material had been placed in scows and dumped at other locations in late 1898.[43] In addition, much of the material dug out of the forebay was a very fine sand. It was ideal for filling between the piles, but did not slope well on the outside. There it slid down onto a very flat embankment, so that a large volume was required to bring the fill on the sides up to the top of the sheet piling.[44]

With coffer dam filling running further and further behind schedule, despite day and night operations, von Schon was compelled to take steps to expedite matters. On July 1, 1899, he arranged for E.D. Smith and Company to use the power house coffer dam as a dump for some of the materials they were excavating from Section III. Bringing in this additional plant speeded matters up, and the coffer dam was finally completed on October 16, 1899. (See HAER photo 47)

After completion of the coffer dam, Mason and Hodge's pumps began to drain water out of the lower forebay and power house foundation area so that additional excavation work could begin. This work, undertaken in the winter of 1899 and 1900, was among the hardest anywhere on the project. Even after most of the water had been pumped out, the area was a mass of soft, sticky clay. Men had to work knee deep in a morass that made even ordinary movement hard work. The water-saturated clay and mud was so heavy that the shovel work soon exhausted the work crews. Under these conditions the onset of winter and low temperatures was almost a blessing. The clay and mud froze and easier to work with. In January 1900, however, a rare thaw once more transformed the site into a quagmire. Mason and Hodge's crews walked off the job, complaining that the work was too hard and threatened not to return unless their wages were raised from 17.5¢ to 20¢ an hour. The strike was quickly settled, von Schon warning that he would bring in 500 outside laborers to replace those who left their jobs.[45] By early March 1900, before the ground had thawed out again, the work of excavating the power house site had been completed to the point that foundation construction could comence.

Von Schon had hoped that relocating the power house 100 feet south of original plans would provide him with a solid clay bed for his foundations. Excavation of the area proved that this was not the case. The dip in the clay slope from east to west placed the western end of the foundation level several feet above the natural clay bed. Moreover, where a small creek had once entered the river, near the center of the projected power house site, a silt seam penetrated well below foundation level.

The silt pockets discovered in the clay and the generally irregular nature of the clay formation compelled von Schon in early 1899 to redesign his foundations.[46] The weight of the power house, he decided, could not be placed on the clay. He substituted for the 1050 hardwood strain piles originally planned, 10,080 softwood bearing piles, 20 to 30 feet long. These were to be spaced 3 feet apart running the length of the building and 3.5 feet apart across the width and were to be driven to refusal, that is, until it required 12 blows of the 3000 pound pile driving hammer to drive them one foot. To further insure the safety of the new foundation von Schon planned to drive 6-inch thick sheet piling, built-up from 2-inch thick planks, 8 to 16 feet down around the entire foundation.[47]

Mason and Hodge began driving foundation piles on March 7, 1900, but discontinued work on March 15. Following von Schon's instructions most of the piles they had ordered for the job were 20 feet long, with none exceeding 30 feet. In order to drive many piles to refusal, they had discovered, lengths in excess of 30 feet were needed. Mason and Hodge objected to furnishing piles longer than 30 feet since von Schon had not specified such. The dispute between the power company and Mason and Hodge was finally settled in April and driving resumed on April 14, after about a month's delay.[48] Most of the piles longer than 30 feet were supplied by the power company to Mason and Hodge, who paid the power company for them, apparently, at the rate per foot specified in the original contract.[49] The job was not completed until September 29, 1900, severe delays occurring because of difficulties encountered in securing piles of sufficient length.

As Mason and Hodge's two pile drivers worked their way across the foundation area workmen followed. They sawed off the piles to a uniform elevation of 564 feet above sea level. The piles were then capped by 12-inch flattened log timbers running the width of the building, secured by 18-inch bolts. On top of these timbers another layer of 12-inch timbers was placed which ran the length of the building. These two layers formed a grill. As the grillage work was completed, concrete, mixed according to von Schon's specifications, was deposited in the grillage and rammed into place in 1.5 cubic yard batches. (See HAER photos 48 and 49) After the concrete had set for several seeks, work began on setting the forms for the monolithic tail race (or tail pit) wall bases. The first of these forms was placed in August 1900, before the pile driving had been completed. By September 1900 several of the pit wall bases and pit floors had been poured.

After the tail race floors and wall bases had aged, the tail race walls were built up with pre-moulded concrete blocks. Concrete block moulding had begun almost a year earlier. In the summer of 1899, while the coffer dam was still being filled and before foundation construction had begun, a stone crushing plant was established in the forebay area. (See HAER photo 50) Boulders were fed into this device to produce stone for the concrete aggregate. In the late summer of 1899 moulds for the concrete blocks were built, and in the fall a concrete mixer was brought in. Von Schon's specifications for the pre-moulded blocks had called for hand-mixed concrete, because von Schon believed that many concrete mixers did not use the proper mixing procedures. In September, at von Schon's insistence, tests were made using the company's testing machines to determine the comparative strength of hand-mixed and machine-mixed concrete blocks.[50] The tests proved the validity of von Schon's position. In October and November of 1899 sub-contractor T.H. Riddle began the manufacture of concrete blocks using hand-mixed concrete. This work was called to a halt in mid-November by the onset of freezing temperatures.

Work on block construction was resumed in the spring of 1900. In May or June a new concrete mixer was installed, one which met von Schon's standards,[51] and the rock crushing plant was put back into operation. Block making proceeded at a rapid pace through the spring and on into the summer. By the time the tail race wall bases had been poured and aged, a large number of the blocks for the walls were on hand. (See HAER photo 51) The first block was set on September 11, 1900, with little ceremony. (See HAER photo 52) By November 1900, when the foundation was completed, a few of the tail race walls had begun to take form and concrete block moulding was almost complete. (See HAER photos 53 and 54)

During the winter of 1900-1901 work on the sub-structure proceeded at a very slow pace since it was not safe to pour concrete during freezing weather. Some experiments were carried out in an attempt to find a good method for laying concrete in cold weather,[52] and a few pit wall blocks were placed, but that was about all. Most of the effort in February and March of 1901 involved moving the moulded blocks from the lot where they had been stored to their proper positions in preparation for the 1901 construction season.

As warmer weather arrived in April work on the power house again picked up. By April masons were erecting the falsework for pouring the tail race roofs over some of the completed walls. By May most of the monolithic bases and tail race floors had been poured and most of the walls constructed. (See HAER photo 55) By July 1901 the sub-structure of the power house had been substantially completed.

Erection of super-structure steel columns and beams over completed portions of the sub-structure began several months before the last tail race roof was poured. Structural steel for the super-structure had begun to arrive at the site in late 1900. By January 1901 most of the steel for the power house was on the grounds. Work with this material began in April 1901 in the penstock area and proceeded at a fairly rapid pace. By July 1901, for example, all the steel work below the second floor (the Carbide floor) was practically completed. As the steel work rose, masons began work on the walls of the power house and the penstock partition walls. By the end of the summer of 1901 a good portion of the work on the penstock-generator floor had been completed. Of 81 planned turbine chamber steel bulkheads, 61 had been installed, and 32 of the penstock units had completed walls. Moreover, the actual installation of the turbines themselves had begun. (See HAER photos 56 hrough 59)

Work on the super-structure continued through the fall of 1901 and was pushed, though frequently interrupted by bad weather, through the following winter. By the beginning of the spring of 1902 Mason and Hodge were installing structural steel on the second mill floor (the third floor on the west end of the building) and one of the supplemental floors (fourth floor segments). In April work resumed at full steam.

Twenty-two masons were employed on the erection of the stone walls on both sides and the ends of the building. By the end of spring the Carbide floor (second floor) of the power house had been largely concreted, the steel frame work for the roof was almost finished, and the roof itself half completed. (See HAER photos 60 and 61) By July the external masonry walls were done and the concrete for the second floor had been placed over all except a 10 penstock length. (See HAER photo 62) The roofing was on save for the east pavillion as well. By October 1902 the building was completed -- almost two and a half years behind the original schedule.

THE TURBINE INSTALLATION

Construction delays and disputes with construction contractors were not the only problems which plagued the company between 1898 and 1902. Problems were also encountered in the projected turbine installation. The contract for the turbines had been awarded to Webster, Camp and Lane in 1899, with acceptance of the manufactured products by the power company contingent upon the turbines meeting certain power, efficiency, and discharge criteria as determined by Holyoke tests of a trial unit. (See HAER photo 63)

These tests began in March 1900. The type of turbine offered to the MLSPC had previously been tested by J. W. Jolly in a vertical setting, and it was upon the results of those tests that Jolly and Webster, Camp and Lane based their expectation of complying with contract requirements.[53] Von Schon had been suspicious of using data from vertically-tested turbines in designing a horizontal plant and for this reason had insisted on including Holyoke tests in his specifications. The results of the first tests on a pair of the Jolly-McCormick units situated horizontally confirmed his suspicions. At the required speed of 180 r.p.m., they fell about 13 h.p. short of the required 282 h.p.[54] This failure meant the contractor would have to modify and re-arrange his turbine runners and draft cases in an attempt to meet contract specifications or give up the contract. It also meant additional Holyoke tests. Because von Schon was needed in the "Soo" to supervise construction, he had the company retain Gardner S. Williams of Cornell to direct the additional tests on modified units.

Gardner Williams (1866-1931) was a rising figure in American hydraulic engineering at the turn of the century. An 1899 graduate of the University of Michigan, he had gained extensive experience in hydraulics while working with the Board of Water Commissioners of Detroit from 1893 to 1898. He had then taken charge of the hydraulic laboratory of Cornell University, one of the earliest facilities of its kind in this country. He was already, by 1900, becoming widely known for his experimental work, and further recognition came shortly after his engagement with

Clergue's organization. Experiments which he had carried out while in Detroit were published in the Transactions of the American Society of Civil Engineers in 1902 and won him that organization's Norman Medal. Later in his career he was a private consultant, specializing in water works and water power. He introduced specially-designed stream line draft tubes in a number of hydroelectric plants and the open-flume scroll setting for vertical-shaft turbines. He became a leading advocate of the arch form of dam construction, developing an international reputation in the field. His last major multiple-arch dam was a 101 arch structure built on the Ural River in the Soviet Union.[55]

Under Williams' direction and supervision tests were carried out on modified Jolly/Webster, Camp and Lane units off and on through most of 1900. Attempts were made to doctor the wheels by leveling off the discharge edges of their runners, by increasing the distance between runners by enlarging the draft cases, by alterations in the form of the discharge cases, by lengthening and enlarging the draft tubes, by altering the form of the center bearing on the shaft in the draft case. Modifications of some sort or another were tested in late March and early April 1900; in May; in August; and, finally, in late November and early December 1900.[56] There were times during this testing period that von Schon despaired of securing wheels which would meet his specifications without massive alterations to both the turbines and the already-designed penstock chambers. In May of 1900, for example, he wrote to Williams:

> It begins to look as if we are not going to rescue the wheels already constructed and that it is absolutely necessary that the Contractors at once enter upon new plans which may require a change in our power house construction . . .[57]

These difficulties, on top of the problems which he was already encountering back in Sault Ste. Marie, must have had von Schon thoroughly depressed.

By late in the summer or early in the fall of 1900, however, it had become clear that some modification on the existing wheels, or wheels manufactured from new patterns slightly modified from the original patterns, would be able to give results equal to or better than the contract requirements.[58] For one pair of wheels the contract had required at 180 r.p.m.'s an efficiency of 80%, a discharge of at least 195.5 c.f.s., and 284 h.p. By December 1900 tests on modified wheels were yielding at specified discharge (195.5 c.f.s.) efficiencies as high as 81.5% with 289 h.p.[59]

Matters were delayed further by a dispute between Williams and Holyoke engineers over methods used in measuring the flow of water into the test flume. The difference between William's measurements and the Holyoke measurements were about 2% just sufficient to drop the efficiency performance of the turbines below contract specifications.[60] This matter was not completely cleared up until early in 1901.

Some of the material for the turbine installation was received in the "Soo" before the end of 1900. Included in these early shipments were the draft tubes and 6 carloads of turbine castings. By March of 1901 20 complete turbine units had been received, excepting the runners. Actual turbine installation began in May 1901. The first turbine case was put into place in penstock no. 1, on the extreme east end of the building, at a time when only penstocks 1 through 11 had been completed. The turbine runners began to arrive in June 1901, and through the summer and fall of that year Webster, Camp and Lane installed turbines and tested penstocks for water tightness, making repairs when needed. (See HAER photos 64 and 65) By August of 1901, 6 units were complete, 10 more almost so. Work on turbine installation continued through the winter of 1901-1902 at a slower pace. By May 1902, however, the 40 units originally ordered were all in place and most of the necessary work completed. For some months afterwards Webster, Camp and Lane kept a small work force in the "Soo" making adjustments and installing a few lost or missing parts. But even this portion of the work was substantially finished in the summer of 1902. Two additional Webster, Camp and Lane units were ordered sometime in 1901 or 1902. These additional units were installed in penstocks 41 and 42 before December 1902.

CONSTRUCTING THE AUXILLIARY WORKS

Construction work on most elements of the MLSPC hydroelectric plant began either in 1898 or 1B99, or, at the latest, in 1900. Bids were not even asked, however, on the two most important auxilliary works -- the headgates and the compensating gates -- until early in 1901, and construction did not begin until mid-year.

Work on the movable dam or headgates was held up by several things. Indecision on the final location and form of the works and the E.D. Smith Company's delay in undertaking work on the lower intake were chief among them. Construction, however, was started in early October 1901. The first job was excavating the rock to a depth of two feet below the canal bottom for the foundations. This was completed by the end of November, and in December the contractor for the sub-structure, H.E. Talbott, installed a cement plant on the site. Work was continued at the site through the winter by enclosing the entire location with wooden shacks. (See HAER photo 66) During January and February the floor sills and some of the anchor rods were set and some work had begun on the masonry piers. By the end of March 1902 the three piers and two abutments on the site were completed. (See HAER photo 67) The houses enclosing the works were removed. In the spring the arches which linked the piers at the rear of the headgates were placed. By June the sub-structure contract had been completed in an "eminently satisfactory manner" by Talbott.[61]

The Dominion Bridge Company, which had the contract for the superstructure, did not begin erection until late June 1902, and worked through most of the summer erecting the steel towers on top of the masonry piers and placing the vertical steel gates with their machinery and counterweights. They finished only in October.[62] (See HAER photos 68 and 69)

Construction work on the compensating gates was also delayed by indecision on form and location. Work did not begin until June 1901 under the direction of assistant engineer G.F. Stickney.[63] Most of the summer of 1901 was consumed in constructing the breakwater. (See HAER photo 70) This was completed by late September and the work effort shifted to the erection of the coffer dam which was to surround the site of the 4 stoney sluice gates. The coffer dam was composed of 4 cribs of 12" x 12" timber, each crib was 16 feet wide by 12 feet high. They were sheeted with layers of 1-inch plank, covered with canvas on the water side, and filled with sand. These were in place by the end of November. (See HAER photo 71)

Pumps were set to work draining the inside of the dam almost immediately. Pumping the side completely dry proved impossible. Stickney found that the river bed contained numerous rock seams that continued to spout water despite all attempts at caulking. He thus had to construct a sump and keep pumps constantly in operation to keep the site even relatively clear of water. By early December 1901 H.E. Talbot crews had begun excavation for the pier and sill foundations.

Conventional construction policy for the onset of winter conditions was to shut down and quit work for the season. But because of the late start of construction here this policy was rejected. As in the case of the headgates, the rather unique expedient of building housing over the entire construction site was adopted. These structures were erected between January 4 and January 16, 1902. Temperatures inside the buildings were maintained at around 40°F at times when the outside temperature was below -20°F. This allowed concrete work to begin in early February. By early March the foundations were completed. Pier work began on March 10, the buildings were removed in late March and early April 1902. By April 10 the sub-structure was complete except for setting the roller tracks in the pier grooves for the gate sections. This work was completed by the end of April and the pumps were finally stopped. The Dominion Bridge Company erected the super-structure, save for some riveting, between April 17 and May 5. By June 15, almost exactly a year after construction had begun, the gates were completed.[64] (See HAER photo 72)

Shortly afterwards the southern and downstream portions of the coffer dam were removed and the embankment connecting the gates to the Canadian shore above the 10th span was completed. When the power canal was opened in late 1902 and early 1903 half of the coffer dam and the long breakwater in front of the works were still in place and the works planned for spans 7 and 8 remained unbuilt.[65] (See HAER photo 73 and HAER drawing, sheet 8 of 8) Clergue and Douglas apparently felt that the works that had been built were sufficient to allow a diversion of around 10,000 c.f.s. and that this diversion was sufficient to provide power to meet immediate contract requirement and other needs. They planned to expand the works as Union Carbide expanded its plant and as other customers for power were found.[66]

THE ELECTRICAL INSTALLATION

The portion of the hydro development most affected by hesitancy and indecision was the electrical installation in the non-Carbide section of the power house. Only in late 1901 and early 1902 were steps taken to finalize plans here. In October 1901 von Schon wrote to Horry of Union Carbide asking for some time for consultation on this subject. The company, he explained, was contemplating an order for generators for 5000 h.p. Around 3000 h.p. were to be used in the form of 2000 volt alternators for street cars and "other" uses. Of the remaining power around 1000 h.p. was intended for electric lights.[67]

Specifications for tenders were sent out to manufacturers on November 9, 1901. These specifications could not be located, but indications are that the installation begin contemplated on that date was to be primarily alternating current, with perhaps a few d.c. circuits for street railway service. In a letter written in December, the electrical engineer assigned by the Consolidated Great Lakes Corporation to the project, W. Owen Thomas, commented that the company was planning to install enough d.c. machines to cover about half of the anticipated d.c. load, with rotary converters providing the other half as needed.[68] The alternators requested from Stanley were 400 kW 30 cycle, 3 phase, operating at 2400 volts.[69] The low frequency suggests that Clergue anticipated selling the power to some type of heavy industry. The high voltage suggests that this power was to be transmitted some distance from the power plant, probably to an industrial site located on the company's Mission Property. Both a steel mill and the possibility of transmitting the power at high voltages to the lower peninsula were under consideration.[70]

One Westinghouse alternator (375 kW, single phase, 60 cycle) was ordered in December 1901. Why that one unit, and no more, were ordered at that time is not certain. It may have been intended to power lighting circuits in the power house itself. The final decision on the scope of the power company's electrical installation was not made until February 13, 1902. At a personal conference with Clergue, von Schon was instructed to install electrical equipment for 5000 h.p., including the single Westinghouse alternator already ordered. The remainder of the equipment was to be purchased from the Stanley Electrical Manufacturing Company and be installed in penstocks 33 through 42.[71] The contract with Stanley was signed on February 21st.[72] The equipment ordered included:

3, 400 kW direct current generators (600 v.)
5, 400 kW alternators (3 phase, 2400 v., 30 cycles)
1, 400 kW rotary converter
3, 100 kW motor driven exciters
1, 130 kW frequency changer
6, 400 kW transformers (probably 360 to 16,500 v.)
plus switchboards and test instruments.

The first alternator and the rotary converter, along with their switchboards, were to be installed and ready for operation by August 1, 1902, with additional units installed every two weeks thereafter until the contract was completed. It was expected that the company would eventually place orders for 33 alternators.[73]

Thomas was placed in charge of arranging the company generators and switchboard equipment. When he began to work on the problem in late 1901 and early 1902 he found several faults with the design contemplated in 1898. He objected, for instance, to the arrangement of the switchboards and the bus bars. Placing each switchboard panel directly above its generator, he pointed out, would have spread the switchboard over almost an eighth of a mile and made it difficult, if not impossible, for one man to operate the plant. Original plans called for connecting the generators and switchboards to a continuous set of bus bars running the length of the plant. This, Thomas noted, would have led to bus bars of enormous dimensions and would have meant that a short circuit anywhere could shut down the whole plant.

Thomas attempted to place the basic means for controlling all 33 company units within easy sight and reach of a single operator. He divided the projected switchboard into three sections with 11 generators per section, and arranged these three sections to form 3 sides of a square, with the operator placed in the center. With conventional 2-foot wide switchboard panels, this would have still meant an enormous area of switchboard panelling. Thomas, however, persuaded Stanley to redesign their instruments so that they would set edgewise in switchboard panels of only about half the standard width. Like instruments in this array of panels were to be arranged in the same horizontal plane, so that a glance at the edgewise instruments with their horizontally-situated pointers should have provided a continuous unbroken bank around the operations room. Any variation could easily be noted.

To reduce the size of the bus bars and the dangers of short circuiting, Thomas redesigned other elements of the plant. He planned two sets of bus bars, with each feeder and generator having a double-throw switch, so that it could be connected to either bar. If one shorted out, only half the plant would be shut down. None of the main circuits were brought directly to the switchboard as in the earlier design. All control over the generators was by means of remote electrically-operated switches. The bus bars in the plant were to act mainly as load equalizers, with feeders tapping off the bars where the generators tapped in. Since only a small per cent of the station output was to flow over the bus bars for any considerable distance, bus bar size could be reduced. Thomas also planned to install pilot solenoid circuits to protect the installation. These oil-immersed switches on a shunt circuit would be held closed by current flowing at normal levels, but would automatically when overloaded or when no voltage flowed.

The direct current units in the plant Thomas planned to connect in parallel with a large chloride storage battery of 144 cells. This battery, rated to maintain a discharge of 500 kW for 8 hours, was to help regulate the d.c. output and absorb the excess power produced by the generators. For power transmission outside the plant Thomas planned to install Stanley water-cooled, oil-insulated transformers, which would step up the voltage to around 15,000.[74]

Thomas worked through early 1902 determining the location for the machines which the company had ordered and designing a temporary switchboard. The Westinghouse machine was delivered in May 1902, and by July Thomas had it and its 75 kW exciter in place and ready to begin operation on two weeks' notice. (See HAER photo 74) The Stanley alternators began to arrive in August. (See HAER photo 75) One of these units and the rotary converter (See HAER photo 76) were in place and connected to the temporary switchboard (See HAER photos 77 and 78) in time for the grand opening celebration in October 1902. By November all of the Stanley equipment had been received and by December or January 1903 the power company's electrical plant was completed. (See HAER photo 79) It consisted of 6 alternators, 3 d.c. generators, plus a rotary converter and a belt-driven exciter unit for the Westinghouse alternator, all connected to a temporary switchboard.[75] Two Lombard governors (type D) with electrical speed controlling devices for turbine, and hence generator, velocity regulation were also installed.[76] The temporary generator-level switchboard was moved shortly after the grand opening to an elevated platform placed on the wall directly above the generators.[77] Because the additional units contemplated beyond the initial Stanley order were never purchased most of Thomas' ideas were never put into practice.[78]

It was anticipated in 1902 that Union Carbide would order 42 Westinghouse 375 kW, single phase, 60 cycle, 90 volt alternators and 2 Westinghouse 220 volt, d.c. generators as exciters.[79] In 1903 Union Carbide ordered and installed:

- 19 Westinghouse 375 kW, single phase, 90 volt, 60 cycle alternators
- 3 Westinghouse 375 kW, two phase, 220 volt, 60 cycle alternators
- 2 Westinghouse 375 kW, 250 volt d.c. generators.[80]

The two phase alternators seem to have been placed opposite penstock units 1 through 3, while units 4 through 22 were occupied by the 19 single phase alternators.[81] Each alternator had its control panel placed on the gallery directly above it.[82]

Union Carbide was informed on January 2, 1903, that the Michigan Lake Superior Power Company was ready to furnish power.[83] Most of the Union Carbide generators and switchboard equipment were installed in the next 12 months. A dozen of the generators were put on furnace load on December 23, 1903, and by January 16, 1904, all 19 of the single phase units were in operation. The two phase units were used for lighting and general power.[84] In January 1906 the power company alternators were also put on furnace load, practically no other customers for their power output having been found.[85]

THE LABOR PROBLEM

As we have seen, there were a number of factors behind the tardy completion of the Michigan Lake Superior Power Company hydroelectric plant. Among them were the late issuance of contracts in 1898, problems in getting materials, unexpected construction difficulties (bank collapse in Section III, for example), inadequate construction plant, and failure to carry out the instructions of the chief engineer. An additional problem which affected just about every facet of the project was labor shortage.

Sault Ste. Marie, Michigan, around 1900 was a town of approximately 10,000 people. The canal project at times employed from 1000 to 2000 men and perhaps more.[86] The region simply did not have a sufficient reservoir of cheap, seasonal labor to support a construction project of this magnitude. As early as August 1899 von Schon wrote a number of employment agencies asking from 200 to 300 men now, more next spring.[87] In a letter to U.S. Assistant Engineer Clarence Coleman, at Duluth, in October 1899 he commented that he was "much hampered at this point in concrete work for the want of experienced men".[88] In October of 1901

Table 9:

Generator Installations in Turn-of-the-Century Hydroelectric Plants
(from Adams, p. 118) (Alternators only)

Location of System	no. alternators	kW each	voltage	Phase	Freq.	RPMs
SAULT STE. MARIE*	80	400	2400	3	30	180
Niagara Falls #1 & #2	21	3750	2300	2	25	250
Electra to San Fran.	5	2000	--	3	60	240
Virginia City	2	750	500	3	60	400
Colgate to Oakland	4	1125	2400	3	60	400
Colgate to Oakland	3	2250	2400	3	60	285
Portsmouth to Pelh'm	1	2000	13200	3	25	83.3
Portsmouth to Pelh'm	2	1000	13200	3	25	94
Ogden & Salt Lake	5	750	2300	3	60	300
Chaudière Falls	2	750	10500	3	66.6	400
Yadkin River Falls	2	750	12000	3	66	166
Lewiston, Me.	2	750	10000	3	60	180
Canon Ferry to Butte	10	750	500	3	60	157
Apple Riv. to St. Paul	4	750	800	3	60	300
Edison Co., L. Angeles	4	700	750	3	50	--
Madrid to Bland	2	600	605	3	60	90
Canon City to Cripple Creek	3	450	500	3	30	--
St. Hyacinthe, Que.	3	180	2500	3	60	600
Great Falls to Portland, Me.	4	500	10000	3	60	225

*Number of units contemplated at Sault Ste. Marie, rather than the number of units actually installed. The plant was designed to power 80 generators; it was not to power that many until c. 1916-17.

The actual installation at Sault Ste. Marie, c. 1905 was:

no. alternators	kW each	voltage	Phase	Freq.	RPMs
21	375	90	1	60	180
3	375	220	2	60	180
5	400	2400	3	30	180
1	375	?	1	60	180
30					

he reported to Clergue that there were barely enough men to keep excavation going in the forebay area.[89] At about that same time von Schon was trying to secure 400 to 500 men, "making efforts . . . at many point(s) throughout the country".[90] The Michigan Lake Superior Power Company at this time was offering employment agencies and labor contractors $1 per head for any laborers that they could recruit, plus free transportation to the "Soo". The results of these efforts were often disappointing. For example, one contractor brought in 48 head in 1901. Only 5 of the 48 reported on the fifth day of work, many worked less than a day.[91]

ACCIDENTS DURING CONSTRUCTION

No record seems to have been kept of the number of construction casulties at the Michigan Lake Superior Power Company works. Local newspaper reports indicate that already, by November 23, 1899, 5 men had been killed in canal construction.[92] The most frequent cause of fatal accidents was the dump trains. For instance, in November 1899 a local resident, Frank Healey, serving as a brakeman on a dump car was thrown between two cars when his train ran off the tracks. His feet were caught between two cars and he was dragged over the road until the train stopped. By that time his head was a mass of blood and bruses and the base of his skull was fractured. He died less than two hours later.[93] On November 15, 1900, a driller for the E.D. Smith Company was killed by an empty dump train that was backing up. In this case the victim, Charles Bevan, was walking on the tracks and did not hear the train approach him from the rear. A car passed over his body, seavering his head from his shoulders.[94]

In addition to on-the-job accidents, construction work sometimes injured or killed uninvolved local residents. In July of 1900, for instance, Mr. and Mrs. Anthony Guillard were thrown from their wagon when their team bolted, frightened by the approach of a dump train locomotive. Their wagon, loaded with farm machinery, passed over both their bodies. Both died within days from severe internal injuried, leaving an infant son.[95] In other instances teams of horses were frightened by the steam of a pile driver, or by the blasts used to break up rock, injuring or killing their drivers or bystanders.[96] The death toll for all stages of construction between 1898 and 1902 may very well have exceeded 25.

TESTING THE PLANT

As one portion of the hydroelectric development after the other was finally completed in the summer and fall of 1902[97] plans were made for testing the power canal and the power house. The first water was let into the canal on August 11 with the coffer dam behind the power house, as well as the upper intake coffer dam, still in place. A small channel was dug through the latter and water was slowly let into the canal. No problems developed. By August 18, 1902, the water level in the forebay was at 585.4 feet above sea level, about 10 feet above the forebay floor and 19 feet above the foundations. This was only about 3 feet above the surface of the St. Mary's River, but since the coffer dam was still in place on the north side of the power house von Schon had the opportunity of seeing how the power house stood up to a 19 foot head. No problems were detected.

The power house coffer dam was then opened and the canal and forebay areas were pumped out. By August 24, 1902, there was no water in the canal, but water at the normal anticipated level behind the power house. Again no problems were detected. Corps of Engineers' officers, who had been appointed by the Secretary of War to inspect the plant from issuance of a permit to divert water, observed the tests.

Dredges shortly after removing the coffer dam behind the power house. Further tests were not possible at the time because the temporary sluice constructed in the upper intake coffer dam could not give higher water levels and the coffer dam itself could not be dredged out until the War Department issued a permit to divert water from Lake Superior. Although this permit was not issued until December 2, 1902, special arrangements were made with the Corps of Engineers for dredging a cut through the intake coffer dam on October 19, 1902. This permitted the development of a head of almost 15 feet. This head was used to power several token turbine and generator units at the grand opening celebration of October 25, 1902.[98]

THE GRAND OPENING

As final tests were being made to the power canal and power house and as contractors rushed the movable dam to completion, Clergue was making plans for the grand opening celebration. He intended it to be a gala affair, designed as much to attract more investment capital to his enterprises, as to celebrate the canal's completion. Invitations were issued to all members of the Michigan state legislature, to the governor, to heads of the state governmental departments, to the U.S. Congressional delegations from Michigan, Minnesota, and Wisconsin, to a large number of prominent American engineers, to leading businessmen from all over the state, and to representatives of the press. In addition, special trains, chartered at the company's expense, brought investors and potential investors from New York, Philadelphia, Chicago, Detroit, Montreal, and Toronto.

On October 24, Friday, the power company held a feast in the afternoon for the school children of Sault Ste. Marie on the quarter mile long second floor of the power house, with some 3000 in attendance. On the morning of Saturday the 25th there was a large civic and military parade. At noon Clergue's sister, Helen, threw a gold and jeweled switch provided by the Stanley Electric Company, setting two generators into operation, lighting up several strings of arc and incandescent lamps, and setting into motion a street car which ran over tracks laid from the power house to the country club. In the afternoon the citizens of the region were treated to a banquet by the company in the power house, with approximately 5000 in attendence. (See HAER photos 80 and 81)

The more notable guests invited to the "Soo" by Clergue (approximately 400) had an even more elaborate banquet on the evening of the 25th in the Armory, served by waiters imported from Minneapolis by the power company. The speeches delivered by Clergue and others at the banquet painted a rosy picture of the future of Sault Ste. Marie. Indeed, that future seemed assured. The Falls of St. Mary's were being tapped for power, and with cheap power available it seemed only a matter of time until the Michigan "Soo" became an industrial center.[99]

Table 10:

Material used or excavated during the construction of the M.L.S.P.C. hydroelectric plant, 1898-1902

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from Sault Ste. Marie Daily News-Record, October 24, 1902:

1,240,000 cubic yards of rock excavated
3,000,000 cubic yards of earth excavated and dredged
170,000 cubic yards of concrete poured or moulded
90,000 cubic yards of sandstone masonry work
32,000 square yards of sandstone pavement laid
260,000 barrels of cement used
3,500,000 feet of piles driven
22 miles of service track laid

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from von Schon to Maurice Hoopes, February 17, 1903 (General Letters, v. 22, pp. 106-7)

Dredging:	368,260	cubic yards of earth
	778.5	cubic yards of rock
Excavating:	1,643,557	cubic yards of earth
	669,416	cubic yards of rock
Canal lining:	333,700	feet of piles driven
	937,257	feet of logs and sills (12" x 12")
	2,217,557	feet of deck planking
	37,641	cubic yards of puddling clay
	257,394	pounds of spikes and bolts
	426	cubic yards of concrete

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from von Schon (?), "Construction History Report, MS. #2," p. 19

Canal revetment (lining):	367,063	feet of piles driven
	277,245	feet of squared and flatted sills
	302,534	pounds of bolts
	2,630,786	feet of deck planking

CHAPTER V: Footnotes

1. von Schon to E.D. Smith Co., July 19, 1898 (GL 6, 479).

2. Soo Democrat, August 11, 1898.

3. Contracts, 264-268.

4. Ibid., 37-51.

5. Ibid., 252-263.

6. Sault Ste. Marie News, July 4, 1898.

7. von Schon to E.V. Douglas, January 14, 1899 (GL 8, 713).

8. Soo Democrat, February 1, 1900.

9. von Schon to Clergue, April 20, 1900 (PL 3, 355-56).

10. von Schon to Clergue, May 21, 1901 (PL 5, 80-81); von Schon to Clergue, May 24, 1901 (PL 5, 93-95).

11. von Schon to E.V. Douglas, January 5, 1899 (GL 8, 637-38). The progress of construction can only be followed through weekly and monthly reports submitted by von Schon and scattered throughout the General Letter and Presidential Letter books and also in the surviving volumes of Reports, series 2, vols. 1, 3, and 5.

12. "Final Report on Contract No. 1, Dredging in the Intake Channel 1896," (GL 2, 138-43).

13. A bulkhead warf of around 160 feet long was planned for the north side of the intake but was dropped later, apparently for economy reasons. See von Schon to Clergue, December 15, 1899 (PL 3, 82-83).

14. Construction History Report, MS #1, p. 93.

15. Ibid., p. 55.

16. Ibid., p. 58, and "Completion of the 'Soo' Canal," Engineering and Mining Journal, v. 74 (1902) p. 310.

17. von Schon to Clergue, December 1, 1898 (GL 8, 363-67); Report of W.W. Dann to von Schon, October 1, 1899 (Reports, 1, 419-24); C.G. Tudor to von Schon, October 1, 1899 (Reports, 1, 428-30).

18. Contracts, 126-29; Soo Democrat, February 1, 1900.

19. von Schon to Clergue, October 1, 1900 (PL 4, 149-51).

20. von Schon to Clergue, December 1, 1898 (GL 8, 363-66).

21. von Schon to E.V. Oouglas, December 10, 1898 (GL 8, 441-42).

23. for example, Clergue to E.O. Smith Co., October 12, 1900 (GL 13, 490); von Schon to E.O. Smith Co., September 21, 1901 (PL 5, 315-18).

24. von Schon to Clergue, "Recommendations," October 5, 1899 (Reports, 1, 412).

25. von Schon to Clergue, October 5, 1899 ("Survey of One Year's Construction Progress", Reports, 1, 400-01); von Schon to Clergue, June 6, 1899 (PL 1, 451-55; von Schon to E.V. Douglas, August 5, 1B99 (Reports, 1, 317-19).

26. Soo Democrat, June 8, 1899.

27. Soo Oemocrat, December 14, 1899.

28. Soo Democrat, July 19, 1900.

29. Boller to Clergue, October 12, 1898 (Reports, 1, 437-39); von Schon to Clergue, June 6, 1899 (PL 1, 453-54).

30. Soo Democrat, June 8, 1899 and Oecember 14, 1899.

31. von Schon to E.V. Oouglas, November 25, 1898 (GL 8, 316); Report of C.G. Tudor for September 1899 (Reports, 1, 430).

32. ? to von Schon, August 15, 1900 (GL 13, 177).

33. "Review of One Year's Construction Progress" and "Recommendations" in Reports, 1, 398-409, 411-414.

34. von Schon to Clergue, "Review of One Year's Construction Progress," October 5, 1899, p. 398.

35. Besides the weekly and monthly progress reports see Construction History Report, MS #2, pp. 5-11.

36. Construction History Report, MS #2, pp. 1-2.

37. Ibid., p. 3.

38. Clergue to von Schon, October 11, 1900 (VP, 17); von Schon to Thomas Munro, October 15, 1900 (GL 13, 26); von Schon to Clergue, February 4, 1901 (PL 4, 390); Clergue to E.V. Oouglas, November 6, 1900 (VP, 43-45). Munro's report is included with the last item.

38a. Construction History Report, MS #2 p. 2.

39. Gustav Lindenthal in his report on power house repairs to the company in May 1903 stated this (see von Schon, General Report, p. 46): "I should mention, that for the sake of economy, the wooden flooring of the canal bottom and sides had not been continued into the Forebay to the before mentioned shelf (i.e. forebay apron)." Since the original specifications on the forebay can not be located, it is not certain when the decision was made not to line the forebay. It may have been made even before specifications were sent out and contracts issued in 1898.

40. von Schon to Clergue, June 3, 1899 (PL 1, 444-48).

41. von Schon to Clergue, June 3, 1899 (PL 1, 444-48); von Schon to E.V. Douglas, November 25, 1898 (GL 8, 310).

42. Report of C.H. Hollingsworth, March 1, 1899 (PL 1, 96-98).

43. Clergue to E.V. Douglas, June 1, 1899 (PL 1, 427-28).

44. for example, C.H. Hollingsworth to von Schon, September 1, 1899 (Reports, 1, 361-62).

45. Soo Democrat, January 18, 1900.

46. W.W. Dann to von Schon, January 7, 1899 (Reports, B, 280-82). See also the other assistant engineers' reports on pp. 283-293.

47. Albert S. Crane to von Schon (August 1900), reprinted in a letter from O.B. Holley to O.M. Jones, June 5, 1941 (Jf 7.11; Ff 11); see also von Schon, General Report, pp. 8-9.

48. von Schon to Clergue, March 30, 1900 (PL 3, 317-19).

49. von Schon to Messrs. Coolidge Fuel & Supply Co., Mary 7, 1900 (GL 8, 160). The whole dispute is reviewed by O.B. Holley in a letter to O.M. Jones, J-ne 5, 1941 (Ff 11; Jf 7.11).

50. von Schon to Clergue, September 16, 1899 (PL 2, 267-73); von Schon to Clergue, September 27, 1899 (Reports, 1, 384-91).

51. von Schon to J. Jacob Shannon & Co., December 7, 1901 (GL 17, 494).

52. for example, Harrington to von Schon, December 31, 1900 (Reports, B, 17.

53. "Report of Tests of Turbines Nos. 52 and 53 and Nos. 86 and 87 (1900-11-28 to 1900-12-4)," by Gardner S. Williams, p. 6 (filed in flat file drawer row under "Turbines").

54. von Schon to Clergue, March 15, 1900 (PL 3, 274).

55. "Memoir of Gardner Stewart Williams," ASCE Transactions, v. 98 (1933) pp. 1659-62.

56. A description of these changes can be found in the report of Williams cited in footnote 53 above, pp. 6-10.

57. von Schon to G.S. Williams, May 17, 1900 (GL 12, 213).

58. von Schon to Clergue, June 5, 1900 (PL 3, 437-38).

59. "Report of Tests of Turbines," p. 10.

60. von Schon to Holyoke Water Power Company, January 11, 1901 (GL 14, 368): A.F. Sickman to von Schon, January 12, 1901 (GL 14, 447), for example.

61. von Schon to Secretary of BO. of Public Affairs, Dayton, Ohio, July 8, 1902 (GL 20, 303).

62. Construction History Report, MS #1, pp. 4-11, for headgate construction review.

63. "Memoir of George Fetter Stickney," ASCE, Transactions, v. 95 (1930) pp. 1634-35. Stickney later worked with the New York State canal system, supervising much of the enlargement work in the early 20th century. He set up as a consulting engineer, specializing in hydraulics, after that, and was the inventor of the siphon spillway for discharging water through dams.

64. The best description of the construction of the compensating works and by far the most complete account is G.F. Stickney, "The Compensating Works of the Lake Superior Power Company," ASCE Transactions, v. 54 (1905) pp. 346-370. See also Wallon Fawcett, "Compensating Works at the Sault Canal," American Manufacturer, v. 71 (1902) pp. 659-61.

65. von Schon to Shields, June 9, 1903 (PL 7, 312-13); von Schon, General Report, pp. 31-33.

67. von Schon to W.S. Horry, October 3, 1901 (GL 17, 91). Von Schon had written the James Leffel Co. earlier (September 17, 1901, GL 16, 468-87) that the company planned to install 40 units (20,000 h.p.), half a.c. and half d.c.

68. W. Owen Thomas to Geo. E. Fostar, December 13, 1901 (GL 18, 26); Thomas to Crocker-Wheeler Co., December 20, 1901 (GL 18, 68)

69. Contracts 239-51.

70. On the steel plant see Clergue to von Schon, June 23, 1902 (VP, 412) and Clergue to von Schon, June 25, 1902 (VP, 425-26). On long distance power transmission see von Schon to Clergue, October 8, 1902 (PL 6, 494-95); von Schon to Clergue, October 17, 1902 (PL 7, 13); von Schon to Clergue, November 29, 1902 (PL 7, 102); von Schon to Clergue, February 27, 1903 (PL 7, 225); von Schon to C.S. Chesney, September 24, 19D2 (GL 21, 118-19); Clergue to E.W. Cottrell, October 10, 1902 (VP, 500-01); Clergue to J.P. Hughart, October 10, 1902 (VP, 504-05); Clergue to von Schon, February 16, 1903 (VP, 591).

71. von Schon to Clergue, February 14, 1902 (PL 6, 89-90_.

72. <u>Contracts</u>, 239-51.

73. "Electrical Features of the Michigan Lake Superior Power Company's Plant at Sault Ste. Marie, Michigan," <u>Electrical World and Engineers</u>, v. 40 (1902) p. 773.

74. "Electrical Development at the 'Soo'," <u>Electrical World and Engineer</u>, v. 40 (1902) pp. 767-770; "Electrical Features," pp. 773-774.

75. von Schon, <u>General Report</u>, p. 20.

76. <u>Ibid</u>.

77. von Schon, <u>Hydro-electric Practice</u>, p. 364.

78. The control panels for the generators were placed directly above the generators instead of adjacent to one anothers (vf 116a-15, blueprint dated April 28, 1913). Whether these panels were the very narrow type which Thomas asserted Stanley was preparing for the company could not be determined from surviving records.

79. "Electrical Features," p. 773.

80. O.B. Holley to L.H. Oavis, May 17, 1941 (Jf 14.0).

81. <u>Records of Switchboard Output</u>, 1903-1911.

83. Blueprint dated April 28, 1913 (vf 169a-15).

84. Davis to B.F. Fackenthal, Oecember 24, 1903 (vf 17-4); Davis to J.S. Fackenthal, January 15, 1904 (vf 17-10). Oavis was von Schon's successor as chief engineer of the power company. Also <u>Record of Switchboard Output</u>, Oecember 1903 and January 1904.

85. <u>Record of Switchboard Output</u>, January 1906.

86. "The Sault Power Canal," <u>Scientific American</u>, v. 82 (1900) p. 329, reported 1500 men working on the project; <u>Sault Ste. Marie News</u>, February 3, 1900, noted that a force between 2000 and 3000 would be used in the coming year.

87. von Schon to G.S. Richards, August 2, 1899 (GL 10, 92); von Schon to National Employment Co., September 18, 1899 (GL 10, 269); von Schon to C.A. Crego, Central Employment Co., September 21, 1899 (GL 10, 291-92), for examples.

88. von Schon to C. Coleman, October 19, 1899 (GL 10, 403).

89. "Progress Report for the Week Ending October 18, 1901," (PL 5, 411).

90. von Schon to Owen Bowers, October 23, 1901 (GL 17, 223); von Schon to Owen Bowers, November 14, 1901 (GL 17, 365). See also von Schon to G.M. Gardner, November 26, 1901 (GL 17, 441).

92. Soo Democrat, November 23, 1899.

93. Ibid.

94. Ibid., November 15, 1900.

95. Ibid., July 5, 1900.

96. Ibid., December 7, 1899, and H. Marden to von Schon, October 11, 1900 (GL 13, 497) for examples.

97. Descriptions of the 'Soo' hydroelectric plant as completed in 1902 can be found in the following sources: von Schon, General Report on Plant of Michigan Lake Superior Power Co., July 1904, 63 pp. (OCf. Von Schon Reports); "New Water Power Plant at Sault Ste. Marie, Mich.," The Engineer (U.S.A.), v. 39 (1902) pp. 549-51; "The Water-Power Plant of the Michigan-Lake Superior Power Co., At Sault Ste. Marie," Engineering News, v. 48 (1902) pp. 226-29; Frank C. Perkins, "The Sault Ste. Marie Water Power," Electrical World and Engineer, v. 40 (1902) pp. 483-85; von Schon, "Power from Lake Superior," Cassier's Magazine, v. 23 (1902-03) pp. 346-54. There are, however, a number of errors of detail in all of these.

98. von Schon, General Report, pp. 14-15.

99. The grand opening celebrations are described briefly in von Schon, "Power from Lake Superior," pp. 346, 349. The best source is Sault Ste. Marie Daily News-Record, October 25 and October 27, 1902.

CHAPTER VI

FEET OF CLAY
(THE ERA OF PROBLEMS)
(1898-1913)

The grand opening of the power house and power canal was supposed to herald a new era of prosperity and industrialization which the city of Sault Ste. Marie had looked forward to for over fifteen years. Instead it marked the beginning of an era of problems which would delay the full utilization of the power development for another fifteen years. These problems had their seeds in the past but did not really start to materialize until the power development was nearing completion. The events which followed seemed to adhere to the principle that if something can go wrong, it will.

These problems were very complex and interelated but if simplified and categorized they fall into three major areas: 1) Legal battles between the Michigan Lake Superior Power Company, the Chandler-Dunbar Water Power Company, and the United States Government over riparian rights to the St. Mary's Rapids and the maintenance of the level of Lake Superior. 2) Financial disintegration and ultimate insolvency of the Michigan Lake Superior Power Company and its holding company, the Consolidated Lake Superior Company. 3) Major structural weaknessess in the power house foundation.

Before proceeding with a topical discussion of these three elements, it will be beneficial to outline their effect on the ultimate use of the power development.

The MLSPC realized that before it could divert water into the power canal some form of compensating works erected at the head of the rapids would be necessary to prevent the lowering of Lake Superior. Plans were made for these works and the federal government ultimately sanctioned their construction. These works were partially completed in Canadian waters by 1902. The Chandler-Dunbar Water Power Company, however, claimed rights to the water flowing through the rapids and to the bed of the stream up to the International boudnary based on their ownership of land adjacent to the rapids. In view of this riparian claim they challenged MLSPC's right to divert water into the canal or erect compensating works in the rapids unless reimbursed for these concessions. Both the MLSPC and the U.S. Government contested the Chandler-Dunbar claim and the legal battles that ensued lasted until 1913. Until this legal problem was settled the MLSPC could not construct compensating works or divert enough water for full utilization of the power house.

While these suits progressed, the MLSPC ran the power house on the limited supply of water made possible by the compensating gates which had already been erected. When water was let into the canal it was discovered that because of the design of the power house foundation, water was seeping through the forebay and washing out the clay fill between the piles supporting the building and the hydrostatic pressure resulting from a full head of water was pushing the power house into the river. If this problem was not corrected, the power house could never operate at full capacity. An engineer who was studying the power house at later date remarked, "Unfortunately, as was said of a towering bronze idol, 'its feet are made of clay'."[1]

This quote also applied to the MLSPC and Consolidated Lake Superior Company which controlled the canal company. The mammoth industrial corporation Clergue had built by 1903 was established on shaky financial foundations and by the end of that year was in danger of toppling. Consequently, the MLSPC was unable to obtain the money needed to undertake the costly repairs and modifications to the power house.

All these events culminated in what was indeed an "era of problems."

EMERGING PROBLEMS

RIPARIAN RIGHTS

The first mention of possible problems in the use of water power at the "soo" was made in 1889. Dr. Farrand Henry, in an article to the Detroit Free Press, suggested that the building of a water power canal would seriously interfere with navigation by lowering the water at the head of the ship canal, thus necessitating the excavation of the ship canal and the upper river at the expense of the government. General Poe, the head of the district U.S. Army Corps of Engineers, in an answering article in the same paper, however, stated that a canal 100 feet wide and 12 feet deep (a reasonable approximation of the size of the original canal plans for the St. Mary Falls Water Power Company) would not have a noticeable effect on the lake and river levels. He went on to say, "Admitting for the sake of argument that the construction of a water power canal having a width of 250 feet, a depth of 12 feet, and a current velocity of three feet per second, would result in lowering the water surface of Lake Superior as much as six inches, I am still unable to see that it would either be necessary to reduce the freighting capacity of vessels or to deepen the St. Marys Canal or River. A simple, easy, and inexpensive way of remedying the evils which the writer of the article seems to fear would be to reduce the cross section of the river by building a spur dam at the head of the rapids."[2]

Although the St. Marys Falls Water Power Company had contemplated many different canal sizes, the general plan had been a canal 100 feet wide by fifteen deep with a current velocity of four feet per second. A canal of this proportion would have had a flow of approximately 6,000 cubic feet per second and most likely would have required a compensating dam as suggested by General Poe. There is no record that the company had planned any such works, but since they never came close to finishing the canal, the problem was probably never seriously considered.

As noted in Chapter III, von Schon recognized that a canal with an approximate flow of 30,000 cubic feet per second would necessitate the erection of compensating works, and he engaged Alfred Noble to study the problem. In his report Noble stated, "The water power which your company proposed to establish at Sault Ste. Marie, Michigan; will draw from Lake Superior so large an amount of water that the regimen of the lake will be seriously disturbed unless remedial works are executed."[3] The necessity for remedial works, or compensating works as they were commonly referred to, created another right of way problem in addition those Clergue had incurred in trying to secure property for a large canal. The LSPC already had permission form the Canadian Government for construction in the bed of the river, but permission for compensating works on the American side would have to be granted by the Corps of Engineers. This problem, however, was momentarily put aside.

The question of compensating works emerged again when on September 10, 1898, Lt. Col. G.J. Lydecker, District Chief of Engineers for the U.S., concerning the work of the MLSPC. Lydecker, who apparently thought that the company should have consulted him about their project, was affected by the lobbying of the Lakes Carriers Association which was opposed to the canal development on the grounds that it would adversely effect navigation and took an antagonistic approach to the MLSPC. In this letter he suggested the canal would be a hazard to navigation and the company was dredging in navigable waterways without a permit from the Corps of Engineers. He also suggested "the conviction of the company for its illegal act of excavation, and an injunction or restraining order in relation to further work beyond the shore lines."[4]

General Wilson referred the matter to the Secretary of War, Russel A. Alger, who was reluctant to interfere with work of the company until the matter could be studied in further detail. He subsequently ordered an investigative board from the Corps of Engineers convene in Sault St. Marie in November of 1898 to study the development. The board appointed was to be composed of three engineers with Col. Lydecker presiding, which in view of Lydecker's previous attitude meant the board would probably be prejudiced against the MLSPC.[5]

Realizing this board would need some form of reference, the company submitted a petition for the diversion of water into the canal which outlined the company's plans for construction including the compensating works. This petition and subsequent letters from Clergue to Lydecker before the meeting of the board sought to pacify the Corps of Engineers by acknowledging its right to permit or reject developments which could affect navigable waterways. Clergue was a politician by nature and chose to mollify rather than confront people who could have an adverse effect on his plans. He informed Lydecker that he had not realized that their dredging was taking place in what was considered a navigable part of the river and pointed out that the company had made plans for maintaining the lake and river levels. In another letter he stated "We shall take care to have the whole matter prepared for your consideration as you require . . . We of course, admit that any preliminary work we may undertake will be at our own risk, and shall make no attempt to withdraw water from existing channels until our plans have met the approval of the Secretary of War."[6]

When the board met in early November it heard testimony from the company engineers and reviewed Noble's report on compensating works. Clergue also testified saying, "In the opinion of competent engineers, there is no doubt of the efficiency of the plans of the water power company for equalizing the loss of water through its canal, thus maintaining the level of Lake Superior and assuring that the interests of navigation will not be impaired. Instead of being a menace, the construction of the canal as planned will be a benefit to the marine interest."[7]

The most decisive testimony to be given, however, was that of William Chandler, who was part owner and manager of the Chandler-Dunbar Water Power Company, and up until this time employed by the MLSPC as a negotiator in securing right of way from property owners and franchises from the city. He stated that wile he was friendly to and in every way favored the project of the MLSPC and believed his company would not be injured in any way by the present plans of the company, he desired the commission, in considering the plans of the company, to consider the development of water power as a whole, in order that nothing might be done that would interfere with the rights of the Chandler-Dunbar Company.[8] What he did not say before the board and before Clergue was the claim he made in a separate letter to the board saying that "as riparian proprietors our right to the flow of the stream in its natural conditions, without dimunuation or alteration, is inseparably annexed to the soil . . . we claim that our ownership extends over the bed of the stream . . . We ask that in disposing of the questions before you our right to use the water which naturally flows past our riparian ownership may be duly regarded and protectd."[9] What Chandler claimed was that the MLSPC would not only have to obtain permission from the War Department for the diversion of water and the erection of compensating works, but also from the Chandler-Dunbar Company.

When the Board submitted its report on the hearings to the Secretary of War it echoed Lydecker's negative attitude toward the MLSPC canal and supported Chandler's claim. The report stated that Chandler's claim "is asserted to be founded in common law and to be superior to any right which can be conferred by State statutes, such as that under which the Michigan Lake Superior Power Company is operating," and that "before authority to proceed with its work be granted, the company should be required to satisfy the Government that it has a clear and unequivocal title to the water and the right to deflect the same." In reference to the maintenance of lake and river levels the report said that "the Board has examined the plans submitted by the Michigan Lake Superior Company -- and is unable to recommend them for approval for the reason that the works are designed to be located on the Canadian side of the river -- where they would be beyond the jurisdiction of the United States . . . The plans proposed for these remedial works are largely based on theoretical assumption not fully established by observations . . For the reasons above set forth the Board is unable to recommend the approval of the project submitted by this company."[10]

Although the Board had been appointed to report on the MLSPC development, it noticed in its study that many other problems concerning water use in the St. Marys River were in need of attention. The Board recommended "the formation of an international commission, composed of representatives of the United States and Canadian Governments, to further study and regulate the use and development of the St. Marys Rapids, to establish the boundary line through the rapids of the St. Marys River, and to determine an equitable division of the water power privileges of these rapids between the two countries." It further recommended that no developments using the waters should be authorized until this international commission be established.[11]

Obviously if the Secretary of War approved these recommendations, the canal construction would be indefinitely delayed. Clergue must have been taken aback that every negative aspect which was possible had been pointed out by the Board and nothing which could be considered remotely favorable to the company's plans even mentioned. Until this time the company had assumed that the State of Michigan owned the water rights in the St. Marys River and had passed on these rights to the company under the provisions of Act #39 of 1883. No interference from the Federal Government had been expected as long as navigation was not interfered with, and they had foreseen no problems in connection with the Chandler-Dunbar Water Power Company since William Chandler had been a former promoter and stockholder of the original canal company and was now an employee of the MLSPC.

Both Clergue and the company president, Edward Douglas, began to send correspondence to the Corps of Engineers and directly to the Secretary of War, refuting the findings of the Board. In addition to this they sent a special emissary, Chase S. Osborn (editor of the local and paper and later to become Governor of Michigan) to Washington to argue their case.[12] The company's position was basically as follows -- In reference to the Chandler claim to riparian ownership, they contended that the claim could not extend beyond Islands #1 abd #2 which lay in the rapids. The rest was unsurveyed and consequently belonged to the U.S. Government. Therefore, a majority of the water rights were unclaimed and free for development with the exception of that part needed for navigation. In reference to the need for international control over the St. Marys, they stated that water rights had already been extended by the Province of Ontario in the statutes of 1889, by the State of Michigan in Act #39 of 1883, and that the U.S. Government was the only governmental body so far opposed to the canal construction. As for compensating works, the company was willing to submit to any modifications by the War Department. The company would build the works at their own expense and on Canadian soil, and give the War Department complete control over the flow allowed through the power canal to protect water levels. The company further stated that to stop construction now would mean the loss of $600,000 to American investors, prevent the expenditure of at least $3,000,000 more, and be detrimental to the commercial interests of Sault Ste. Marie and the State of Michigan.[13]

The Secretary of War Alger was sympathetic to the plans of the MLSPC and the reaonsable explanations for this. Alger had been one of the original stockholders of the first canal company organized by Seymour in the 1870's. He had since that time risen in politics. He had been elected Governor of Michigan in 1884 and appointed Secretary of War in 1897. Another reason he may have ignored the recommendations of the Board is that there were deep jealousies between the officers of the line and the bureaus that governed them at that time, and Alger may have taken a dim view of the opinions of his subordinates.[14] This sympathetic attitude to the canal development was reflected in the decision Alger reached in the matter of Federal interference. On March 22, 1899, Alger sent a letter to Douglas, a portion which read as follows:

> Referring to your application for permission to construct certain works in the St. Marys River, and a canal which shall tap the waters of Lake Superior near the mouth of said river in the State of Michigan, I have to advise you that under your express statement that the works you propose will not, under the plan contemplated, impair or obstruct the navigability of any waters over which the United States has jurisdiction, it is not necessary for this Department to grant you permission or license to execute the works.[15]

In July of the same year Alger visited Sault Ste. Marie, toured the canal development, gave a speech on the great future of water power development in the city, and was wined and dined at Clergue's blockhouse.[16]

The MLSPC proceeded with construction but the problems which were brought to light in this confrontation were just a preview of complications to come. The problem of water rights had not yet been settled, and as long as this condition existed, Clergue could not bring the canal into use without fear of litigation. More importantly, the works necessary to compensate for the diversion of 30,000 cubic feet of water per second could not be built entirely in Canadian waters. It would have to extend into American waters, infringing on the subaqueous lands claimed by the Chandler-Dunbar Company, and it required a permit from the War Department for construction. The exact boundary line through the rapids had never been established, making it an undecided point over who had what permission for granting construction in the rapids and what the division of water flow between Canada and the United States was. The Engineer Board's suggestion of an international commission to study the problem was a good one for there apparently was much to settle in view of the multitude of interests now concerned with the use of the St. Marys Rapids.

Alger's letter to the company seemed to settle the problem of government interference, but the Lake Carrier's Association which had originally brought the canal development to Lydecker's attention was still not satisfied that precautions taken by the company were adequate. Having failed to get the War Department to stop the canal development, the Association took their case to Congressman Burton, chairman of the House Rivers and Harbors Committee. Burton subsequently called for a committee investigation of the MLSPC project and invited all parties to state their case before the committee in February 1900.[17]

These committee hearings were mainly a battle between the Lake Carrier's Association and the MLSPC. The Association initially tried to stop the development all together by having the Rivers and Harbors Committee adopt a resolution that would keep the MLSPC from diverting water. The MLSPC after much consultation with the Association, however, was successful in convincing them that the company's plans for compensating works which now included moveable sluice gates would be beneficial and not detrimental to the navigation interests. It was pointed out that the lake and upper river level varied as much as three feet under natural conditions, causing many problems in deciding how deep a ship could be loaded without grounding. The compensating works, the MLSPC claimed, could be used to maintain the lake level at its highest level and boats could therefore carry much heavier loads without fear of grounding. The Association was apparently impressed by this argument for it decided to sanction rather than fight the canal.[18]

A resolution regulating the MLSPC canal was finally formulated and attached to the Rivers and Harbors Act which was passed by Congress on June 13, 1902. Although this Act authorized the diversion of water into the canal, the Lakes Carrier's Association had succeeded in putting the following conditions on that diversion: The diversion of water could not diminish the water levels in the lake or river; remedial works and controlling works had to be established and maintained by the company; the operation of the canal and remedial works would be subject to the rules and regulations of any international commission which became operative in the future; the Secretary of War had the right to impose any rules and regulations necessary to prevent injury to water levels and navigation; and the Act could not be held to affect any existing riparian or other rights of any person or corporation.[19]

Although this act gave Congressional sanction for the diversion it also stated that an application still had to be made to the Secretary of War for the final authorization to let water into the canal under rules and regulations imposed by the War Department. This permission was given officially by Elihu Root on December 12, 1902, in a permit which reiterated that the diversion could not adversely affect the riparian rights of any other person or company.[20]

These two documents, while giving the MLSPC the right for diversion, indicated that the diversion was to be under the complete control of the War Department and any international commission which might be formed. More important was the clause protecting riparian rights of other parties. This meant that the company had no real control over the water flow through the canal and that a full diversion of water could not be accomplished until the water rights controversy with the Chandler-Dunbar Water Power Company was settled.

Two of the main contestants in the ensuing conflict over water rights were the MLSPC and the Chandler-Dunbar Water Power Company. A brief history of the Chandler-Dunbar Company and of William Chandler himself is needed at this point in view of the drastic effect the man and the company were to have on the future of the MLSPC.

William Chandler was an early promoter of water power development in the Sault, and in following years became more intimately involved in the attempts to develop it than any one person with the possible exception of Clergue. In 1881 had been for several years the collector of tolls at the St. Marys Falls Ship Canal for the State of Michigan. When the Federal Government took over the locks in that same year, he became superintendant of the locks and a federal employee. Chandler must have been stimulated by Seymour's formation of the water power canal company in the late 1870's, because in 1881 he filed a claim in the government land office on land which lay in between the government locks and the rapids.[21] On this land he planned to establish a water power company of his own.

In light of his government post as locks superintendant at the time, this acquisition of land can only be viewed as a conflict of interests, especially since the land in question had been purchased from the Indians by the Federal Government in 1857 for the specific purpose of future construction of ship locks. When the matter of acquisition came up in later years it was suggested that this land was sold to Chandler by a mistaken clerk who did not realize what property was being processed.[22] Even though the process was legal, the means through which Chandler obtained this land can only be considered "shady."

When the first St. Marys Falls Water Power Company was formed in 1885 by local citizens, Chandler was one of the original ten stockholders. He was also appointed the agent and representative of the company to raise additional capital, secure right of way property, and make contracts for construction.[23] He retained this position after reorganization with the LaCrosse Syndicate and up until the time of the company's demise in 1893. In the meantime, Chandler had organized the Edison Sault Light and Power Company which began a small power development in 1887 on the lands Chandler acquired in 1881. In 1888 a small canal, power house, and electric light plant had been finished and the company began supplying the city with electric service. Generation and distribution problems ensued. The water power canal as constructed, was inadequate and ice conditions hampered winter operation. Due to the many mechanical and operational problems, service was less than desirable and the company soon encountered financial problems and became insolvent. In 1891 the company mortgaged its assets to Harris T. Dunbar who subsequently obtained these assets by foreclosure in November of the same year.[24] Chandler still owned the property and the water rights so it was natural that the two merged to form the Chandler-Dunbar Water Power Company.

The Edison Sault Electric Company was formed to redevelop the original canal and power house in which Chandler and Dunbar were the holders of the majority of the stock with the addition of the Edison Electric Light Company and others as minor stockholders. The existing headrace was enlarged and plant operations improved so that in 1892 the company continued electric generation with a greater degree of success.[25]

In 1893 Chandler was manager of the Sault Savings Bank with the title of Treasurer when the mortgage was foreclosed on the St. Marys Falls Water Power Company. His bank and two others subsequently held ownership of the canal right of way and all of the work done to date. In 1895 when Clergue and the LSPC expressed interest in acquiring the canal rights, Chandler as manager of one of the controlling banks and as a man who had a detailed knowledge of canal matters, was a natural selection as negotiator in arranging the sale of the canal to the prospective buyers. This he successfully did and in so doing must have impressed Clergue for he was immediately retained by the LSPC in the same position as he had held with the St. Marys Falls Water Power Company, that of right-of-way negotiator and public relations man for the company on the American side.[26] From 1895 through 1898, Chandler was intimately involved in the acquisition of property for the proposed larger canal and spokesman for the Lake Superior Power Company in soliciting the citizen's and city's cooperation for the new owners.

In 1895 Chandler announced the proposed expansion of the Chandler-Dunbar power development in the rapids. The enlargement of the head race in 1892 had given that company the capacity of producing approximately 10,000 horse power but in 1895 was only using 600 horse power of that capacity.[27] The plans for further expansion which called for an increase in capacity to 20,000 horsepower could only have been an attempt to assert the company's claim to the right to use a majority of the power available in the American rapids. It is difficult to ascertain whether or not Chandler and Clergue had any working agreement on the ownership of water rights between their two companies but neither apparently saw any conflict arising until 1898. Even after the Board of Engineers hearing in 1898, Chandler continued in the employ of the MLSPC until his election to the State Legislature in December of 1899.[28]

Later records indicate that Chandler's departure from the MLSPC was not on good terms. For the next ten years there ensued a battle between the Chandler-Dunbar Company and the MLSPC over control of the rapid's water power. Clergue had sufficient foresight to realize Chandler's claim to the land and water in the rapids was going to cause problems in the future. In 1900 he began to take definite action in anticipation of the legal battle that would ensue if the MLSPC diverted any water Chandler considered his.

In April of 1900 Clergue had a memorandum brief prepared by his lawyers on the legality of Chandler's claim to riparian rights and on the possible acquisition of Island #5 which lay near the foot of the rapids. The brief indicated that Chandler's ownership could be attacked on grounds that the patent issued by the Government had been issued by mistake and was therefore invalid. Even if the patent was valid, lands sold by the Government gave title only to the waters edge. If this was true, Chandler did not hold title to the water, the subaqueous land in the rapids, or Islands #1 and #2 in the rapids; therefore Chandler could not prevent the diversion of water from the rapids.[29]

The brief also indicated that it might be possible to acquire Island #5 in the rapids which was adjacent to the last 2 to 3 foot fall of water. If Clergue could acquire this island and if Chandler could claim riparian ownership to part of the rapids then so could Clergue. Ownership of Island #5 could also be used to block an extension of the Chandler-Dunbar tailrace to keep them from gaining a higher head of water. On the basis of this report Clergue had his lawyers continue the study of riparian ownership and formed the St. Marys Power Company to develop the water power adjacent to Island #5 if title to that island could be obtained.

By 1901 the water rights controversy began to peak. Chandler, who had not followed through on the expansion plans of 1895, made application again to the War Department for the expansion of the Chandler-Dunbar works. No hearings were held on the proposed expansion and Col. Lydecker who had caused the MLSPC so much trouble in 1898, refused to make the Chandler-Dunbar plans public. Clergue, incensed by the secrecy which surrounded this application, retained new attorneys to pursue the riparian rights issue and revealed his anger at Chandler and Lydecker in a letter to these new attorneys:

> At the time of our application to the Government which was of similar form, notice was given by publication and a formal public hearing held at Sault Ste. Marie. The difference between the course then followed and the Star Chamber methods in the present instance is surprising . . .
>
> I now instruct you on behalf of the MLSPC to pursue this matter as vigorously as you can. I think that perhaps you might persuade Mr. Carliss, Member of Congress to secure copies of all this correspondence for us. Chandler's application, I consider Col. Lydecker's conduct in this matter quite in accord with the impression we have of his dishonesty.[30]

Clergue realized this fight was going to be a long one and one that would decide the future of the MLSPC. The construction of the canal was already costing much more than originally anticipated and if the company was forced to pay for a large water lease from Chandler, then the power produced by the canal was unlikely to be competitive enough to attract users. As the Congressional hearings continued in Washington and the Chandler application was being considered, Clergue mustered his forces. In another letter to his attorneys in August of 1901 he said, "Senator Hanna can be depended upon to intercede for us at any time in Washington. He spent a day here recently . . . We have plenty of support of the strongest kind in Washington when necessary to call it out."[31]

Until this point the legal sparring between Chandler and Clergue had been indirect. In the following letter from Chandler and Clergue to the MLSPC, the first direct confrontation was made:

> As you no doubt know, we claim to be the owners of land bordering on the south shore of the St. Marys River . . . and as such owners of the shore line, we claim to be the owners of the bed of the river to the international boundary line in the St. Marys River over the same . . . Until further advised respecting your claims and purposes we forbid any extension of your works (compensating works)

> from the Canadian shore closing flow of the river beyond the international boundary line . . . If, as we fear, you claim the right to and purpose to divert the flow of said river appurtenant the American side to our said lands, we forbid any such diversion from the river and from our hydraulic works, and if you persist in such claim and purpose, it is quite plain that self-protection requires that we resist such diversion and secure an adjudication respecting our adverse claims to the flow of said river at this point.
>
> If it is necessary that we take action it seems that the earlier we act, the sooner the matter will be settled, and that early adjudication will be to our mutual advantage. Kindly let us hear from you respecting your claims and purposes, that we may further and more intelligently consider the matter and be advised what action we ought to take.[32]

The gauntlet had been thrown and Clergue accepted the challenge. His letter to the Chandler-Dunbar Company made no pretense at civility since he apparently looked upon Chandler as a traitor who had deserted the cause and because Chandler had been a director of the old canal company and had convinced Clergue to buy it.

> Respecting the hydraulic canal under construction by us at Sault Ste. Marie, Michigan, the object of this canal must be perfectly well known to you, since your President was personally cognizant of all the negotiations leading to our purchase of that property, and was for some years on our pay roll as agent for our Company during the commencement and for some time during continuance of its construction. We desire to state, however, that we have not the slightest intention of interfering with the right of the Chandler-Dunbar Water Power Company or any other persons or corporations as we understand them . . . In view of the obstacles your Company have in the past endeavored to place in the way of the progress of our hydraulic development, we do not expect that we can derive any benefit from voluntary action of yourselves, and we have accordingly instructed Messrs. Oren, Webster & More to accept service of writ you may serve on this company.[33]

Clergue's statement that he did not intend to interfere with the Chandler-Dunbar Water Power Company's rights was qualified by the statement, "as we now understand them." Clergue could not help but fight Chandler's claim to riparian ownership if he wanted to save the MLSPC. In April 1898, a report had been compiled by von Schon titled, "A Preliminary Discussion of Water Power Development, Present and Future on Property of the Chandler-Dunbar Water Power Company." This report showed that Chandler could develop water at a much lower cost per horse power than what the MLSPC could with their canal.[34] Thus if Chandler could fill their canal, they could never hope to compete with the Chandler-Dunbar company or offer power rates which would attract industrial users.

After receiving Clergue's reply Chandler decided the only way to stop the MLSPC from diverting water into the canal was through the courts. On March 6, 1902, Chandler filed suit in Chippews County to obtain an order to stop the diversion of water into the MLSPC canal.[35] This action caused much consternation among the citizens of Sault Ste. Marie, for the canal which after fifteen years was finally nearing completion was threatened by this suit. Chandler became the object of abuse by those persons who had worked for the canal's completion and all those who stood to gain from the increased business it would bring. A letter from Clergue to one of his attorneys echoes this sentiment:

> I need not tell you that I regret that our undertaking should be the cause of disagreement between Mr. Chandler and his friends, since you know that there is nothing malicious in my character. Mr. Chandler's predicament is entirely of his own seeking, and the character which he now presents as a blackmailer, is not the result of any action of our company. He has now brought an action against us, hoping by some technicality to prevent the opening of our canal until we shall have submitted to his attempt to extort blood-money.[36]

When Chandler filed this suit against the MLSPC, Clergue decided it was time to fight back. On March 14, 1903, he filed a petition to the War Department under the auspices of the St. Marys Power Company which proposed a water power development and adjacent to Island #5. This development if approved and completed would develop a major protion of the water power available in the rapids. (See Map #2)[37] It is doubtful Clergue actually planned to build this development, but if the War Department approved the plan, it could be considered an acknowledgement that the United States held the right to the rapids water power and not Chandler. Even if the petition was not approved the ownership of Island #5 gave Clergue a claim to a portion of the rapids.

The War Department now had two petitions before it for further development in the rapids, the Chandler-Dunbar expansion plan and the St. Marys Power Company proposal, but it was unwilling to approve either until the legal matter of water rights was settled. Since the MLSPC had the right to divert water under the Congressional Act of 1902, Clergue decided it was in the company's best interest to establish that the water rights belonged to the U.S. Government and not to the Chandler-Dunbar Company. To this effect the MLSPC filed suit in the name of the United States against the Chandler-Dunbar Water Power Company on October 26, 1902, which claimed the water rights in the St. Marys River for the United States.[38] This suit took the place of the one the Chandler-Dunbar Company had filed against the MLSPC. The case was to drag on until 1908, eventually going to the Supreme Court for determination.

In the meantime events would take place which further adversely affected the fortunes of the MLSPC.

LEASING THE POWER

The lack of applications for power generated by the Canadian canal had apparently taught Clergue a lesson which affected his approach to the building of the Michigan canal. He had solved the problem in Canada by using the power himself but it had taken an additional expenditure of capital to build the companies necessary to use that power. The Michigan canal was also going to cost much more than the Canadian canal and Clergue realized that power must be sold to outside users to obtain the money needed to pay off the interest on the bond issue. Consequently he had made the statement that construction on the canal would not begin until a considerable portion of the power was leased. The signing of the Carbide contract in April, 1898, had fulfilled this condition and construction had begun. The Carbide contract had, however, only called for the use of 20,000 horse power which left at least 20,000 more to find uses for.

The earliest expected use for the power Clergue had considered was a pulp mill. In 1895, he made the following statement:

> We expect to have the pulp mill on the American side of the river in operation by the middle of next winter. This mill, which will be known as Mill No. 1, will be as large again as the two mills on the Canadian side of the river combined.[39]

These plans obviously fell through because there wasn't enough pulpwood available on the American side to support a large plant and the Ontario Government would not allow the export of pulpwood at that time.[40]

Flour milling was an industry which had been planned for ever since the canal had first been conceived. The LaCrosse Syndicate which had formed the nucleus of the 1887 company had been composed of flour millers from Wisconsin and Minnesota, and the Sault, in that period of enthusiasm, was constantly referred to as becoming another Minneapolis since it would be milling so much flour. Clergue had not ignored this possible use for power. In 1897 he had von Schon compile a report to answer the question, "Is Sault Ste. Marie a favorable point for the grinding of wheat in transit as compared with Minneapolis" von Schon's findings were that flour milling could only take place profitably here if it was done on a large scale and then only for export to take advantage of the cheap water transportaiton. The major drawback to a flour mill at this location was the handling and transportation costs which would be incurred between the Sault and the market in the East.[41]

In spite of this report, Clergue continued to promote flour milling as a possible industry for power use. In 1898 he predicted that within five years the amount of wheat ground at the Sault would reach 25,000 barrels of flour a day.[42] Four years later in 1902 he was still trying to attract flour interests to establish a plant here. In a letter to a flour company in Minneapolis he stated:

> We now intend to take up seriously the question of the erection of a flouring mill at Sault Ste. Marie, Michigan. Do you think it would be practible to organize a syndicate in Minneapolis and St. Paul to undertake the establishment of such a mill here? The two chief essentials to secure the success of the mill here are first, the cheap assemblage of grain and shipment of flour, and, second, the economical power. We would provide an ideal site, on the dock at the head of the canal on the American side, ships could discharge grain into the elevator and load flour without moving from their berth, while the railway tracks could perform similar functions on the other side of the mill.[43]

This and other solicitations went unheeded, however, and the industry that people had originally thought would build the city into a metropolis never came to pass.

In June 1899, a contract was signed with the American Alkalai Company for 15,000 horse power to be provided by the MLSPC.[44] With this contract and the Carbide contract, the majority of the power produced by the canal was contracted for and seemingly the power development was not going to have the problem of finding users upon its completion. The Alkalai Company was to occupy the west end of the power house, thus not only was the majority of the power leased but industrial space in the power house was leased as well.[45]

Again, von Schon was called upon to compile a report on the availability of salt in the Upper Peninsula which could have only been for salt to be used in the manufacture of alkalai. This report indicated salt could be expected to be found in the limestone deposits in areas 40 miles south of the Sault.[46] Therefore the Alkalai Company would have a source of raw materials close at hand if mineable deposits were found here.

The Alkalai Company, however, held a disputed patent right and complications ensued. It failed to pay rent and other charges under the contract and was forced into receivership by Clergue's company in 1902. Despite efforts to reorganize the company, American Alkalai never reemerged as a viable company and user of power.[47]

Another industry which was planned for but never materialized was the production of white metal. In 1898 Clergue had announced that "negotiations are now in progress for the installation of 10,000 horse power for the electrolytic treatment for the extraction of the silver contained in the copper from the Calumet and Hecia mines (located in the western Upper Peninsula).[48] Not much was heard about this industry until 1902 when a Mr. Craig visited the Sault with his engineer to select a site for the location of a "white metal" plant.[49] A contract was apparently signed for the lease of power, a site for the erection of a plant, and for the purchase of nickel and copper from the company mines in Sudbury, Ontario. The contract would have yielded a "large profit to the company" but by 1903 the fulfillment of this contract was "surrounded by so much certainty" that it suffered the same fate as the Alkalai company.[50]

By 1902, with the exception of the Carbide contract, all plans for power leases to outside users had fallen through and Clergue had to consider planning industries himself as he had done for the Canadian canal. His pessimism on attracting new industry is illustrated by a communication to von Schon saying, "it is possible that demands for power will occur more rapidly than I now anticipate,"[51] but his anticipations were correct. With the plant nearing completion he began planning the use of power which would be necessary to keep the power development from going bankrupt.

Clergue had been negotiating with various manufacturers of paper for the establishment of paper mills in Sault, Michigan, to which the MLSPC would provide free mill sites with the power lease, free stone for building purposes, use of company docks and railway, and pulp provided by the Canadian pulp mill at a competitive price.[52] The terms offered attracted the interest of a J.P. Hummel of Milwaukee, who proposed the formation of a syndicate to build a large paper plant. Apparently Hummel's proposals were unsatisfactory and the deal was never made. The correspondence with Hummel, however, led Clergue to believe that a paper plant would be a very profitable operation and as such should be taken advantage of by Clergue's associates. In Clergue's own words, "A paper mill on the American side is the only thing necessary to round out our pulp operations in a most satisfactory manner. I would be willing to allow a reasonable contribution of our profits to a Syndicate of successful and reputable paper makers joining us in a paper mill on the

American side, but any important contribution for the benefit of such an alliance is entirely unnecessary. A paper mill on the American side will no sooner be undertaken than we shall be overwhelmed by appreciations from the big syndicates for some sort of a combination which will secure for us all the profits we ever asked for.[53]

Clergue's argument was convincing and 1902 saw the planning for a large paper mill to be erected on the site of the terminus of the old canal right of way, and the incorporation of a paper company with Clergue as president. The new company was named the Great Lakes Paper Mills Company and was capitalized at $1,600,000. Contracts for the lease of power from the MLSPC were prepared and preliminary work done on the site started in the fall of 1902 with anticipation of major construction to begin in the spring of 1903.[54]

The new paper mill was not to take up all the power and Clergue still needed to make plans for its disposal. A contract was signed with the Hatch Smelting Company but it only called for a small amount of power as the company was only in the experimental stage of production.[55]

The lack of industries willing to locate in the Sault and lease power led to a desparate move for Clergue -- the contemplation of power transmission to users outside of immediate area. In October of 1902, he began communicating with businessmen in Michigan's Lower Peninsula inquiring on the possibilities of erecting and operating electric power lines from Sault Ste. Marie to Grand Rapids and Detroit.[56] Electrical transmission was a new field but Clergue was an innovator and recognized that one of electricity's assets was its adaptability. He stated that "Recent electrical developments now make possible uses which have been regarded as impracticable, and the advance in coal costs have stirred owners of water power, as well as users of power, to a more active interest in electrical transmission over long distances."[57]

In early 1903, Clergue was having estimates prepared for the cost of a transmission line for 25,000 horse power from the Sault to Detroit, and if they looked favorable, he planned to begin work on the line in the spring of 1903.[58] When these plans were exposed in newspaper articles they immediately drew the criticism and disbelief of Sault residents who wanted the benefits of power to be used in the industrialization of the city. The announcement of this plan was referred to as a "hot air story" and one local newspaper stated "that we do not believe that the company has any intention of diverting power to be generated here to lower Michigan."[59] Citizens of the Sault did not want to believe the story for they had been counting on the power to bring them prosperity.

Besides the problem of finding uses for power the MLSPC was in trouble over the power they had leased to the Union Carbide Company. That contract had been negotiated before construction had even started and when costs for the canal and power house had been estimated at a conservative figure of three million dollars. The final cost including auxiliary structures and equipment was over double that initial estimate and the lease rate of $10 per horse power per annum was much lower than what was needed to provide a return on the investment. The MLSPC, however, could see no way to negate the Carbide contract and would consequently have to charge new power users a higher rate to make up for the low rate given to the Carbide Company.

The problem of finding users of power by 1903 turned out to be no problem at all, for until the water rights issue was settled with the Chandler-Dunbar Company there was no water available and hence no power to lease other than what was already being used by the Union Carbide Company.

FINANCE

The planning and formation of the MLSPC and its canal were only one phase of Clergue's operations between 1895 and 1898. In 1895 Clergue had expressed disappointment over the lack of applications for power produced by the Canadian canal, but in January of 1896 he stated that "it is not a question of securing industries enough for the utilization of the power, but to develop power enough for those already contemplated."[60] This was yet another example of his limitless optimism. When problems evolved he immediately worked on solutions.

When there was a lack of power applications he organized the Sault Ste. Marie Pulp and Paper Company and built a pulp mill. When the pulp mill had been in operation for a short time, the trade rivals of the new enterprise lowered the price of pulp. To meet this challenge, Clergue himself designed a machine which would extract the water from the liquid pulp in order to save freight charges. When he could find no one to build this machine, he built a machine shop and built the machine and dry pulp mill himself. Needing sulphur for the dry pulp process Clergue acquired nickel mines at Sudbury, Ontario, since a by-product of smelting nickel was sulphur.[61]

Clergue's expansion in Ontario was not only out of necessity but due also to opportunity. In 1897 a man named Ben Boyer had discovered a large deposit of iron ore about 150 miles north of the Sault. Since he lacked sufficient funds to explore the deposit, he went to the Sault, showed Clergue samples of the ore, and offered to point out the location for $500. Clergue immediately bought the mine which became the largest producer of iron ore of its time in Ontario.

By 1898 with the formation of the Michigan Lake Superior Power Company, Clergue and his backers had a secure foothold in the two Saults. Through their ownership of the common stock of the Lake Superior Power Company they controlled the power development on both sides of the river, a prosperous pulp mill, and utilities in the Ontario town. The land and power were to provide the foundation for tremendous expansion in the next five years. But in 1898 these holdings were still in their formative stages with the exception of the pulp mill, and were not producing profits to provide additional working and investment capital. It was apparent in 1898 that fresh infusions of new capital were necessary to bring the companies to the point of self-sufficiency.[62]

In January, 1897, Clergue and his associates had procured the incorporation of the American Lake Superior Power Company by Special Act of the General Assembly of the State of Connecticut. This company was originally formed to be an operating company for the Michigan power canal and Clergue had briefly done business for the canal under this name. Plans had also been made to transfer the Michigan properties to this new company. The formation of the MLSPC, however, indicated that this corporation was to serve another purpose. In June, 1898, this purpose became evident when the name was changed to the Consolidated Lake Superior Company and capitalized at $20,000,000.[63] By transferring many of the holdings of the Lake Superior Power Company to the new company the Philadelphia syndicate hoped to attract investors to buy stock in Consolidated and thus gain the working capital needed for future development. Again the financial manipulations of Clergue and his partners worked. The sale of Consolidated stock went fairly well and money became available for further development of Clergue's schemes.

One of the properties transferred to Consolidated was the stock of the MLSPC previously held by the LSPC. The news of the formation of the new company and the MLSPC being part of it was well received by the citizens of Sault, Michigan, as evidenced by the announcement in a local newspaper:

> What the formation of the company means to Sault Ste. Marie there is no need descanting upon. It is as plain as the noonday sun to all who can read. Many more millions of capital than even dreamed of a few years ago by the most optimistic and enthusiastic Sooite upon water power development, will be expended here. The old Soo will be transformed into a new Soo, one of the most important cities in the west. Nobody can longer doubt the stability of the great enterprise, and proper conception of its magnitude will come later.[64]

The formation of Consoldiated was important to the MLSPC for the $2,400,000 secured by the 1st mortgage bonds was to prove inadequate for the construction of the canal and power house. Between April, 1898 and December, 1902, loans approximating $2,165,000 from the Lake Superior Power Company were necessary to complete the structures and pay the interest on the bonds. On January 1, 1903, this debt was consolidated in the form of $2,400,000 of second mortgage bonds, the difference of $235,000 being considered as discount or commission.[65] Without the infusion of new capital from Consolidated, the LSPC, which had become a subsidiary of Consolidated, would not have been able to make these loans.

When Clergue had to start borrowing from the LSPC to pay for canal construction, he started to take more of an interest in the money which was being spent on the Michigan canal. Initial conservative estimates fo construction had been made of three million dollars for both canal and power house. A letter in response to an inquiry about canal costs to date in November of 1900 stated that "the contract of their works completed is about $700,000 less than the proceeds of their 5% bond issue."[66] If this meant the $2,400,000 the MLSPC actually received for construction, then money spent to this date would be approximately $1,700,000. This amount represented progress to date of only two-thirds of the canal excavated and only the foundation of the power house completed. The cost overruns were striking enough for Clergue to write von Schon:

> I have decided that our expenditures on the American side must be curtailed. We are so far exceeding all estimates which we have furnished to Board of Directors as to excite their alarm. You will proceed with no further work other than that now under contract in respect to dredging or erection of wharves at the head of our canal. You will purchase no more materials of any kind without first getting my approval in writing.[67]

From this time forward a close watch was kept on expenditures, and estimates were made of what future expenditures would be. Nothing, however, was going to change the fact that Clergue had underestimated the cost of construction. In November of 1901 estimates showed the final cost at $3,975,959 which included about $80,000 representing materials and labor furnished for other purposes than construction.[68] Based on this figure Clergue began making calculations for power lease prices using a round figure of $4,000,000.[69] But lease prices based on this figure were inadequate. The total cost of the project including subsidiary works and other expenses by 1902 was approximately $6,500,000.[70] Final costs tabulated in 1904 brought this figure to almost $7,000,000 (See Table II).

By the time of the grand opening in 1902, the MLSPC was in deep financial trouble. It owed $5,900,000 on its first and second mortgages, $1,000,000 on unsecured debts to Consolidated, and $300,000 annual interest on its bonds. In order to pay off these debts the MLSPC had to go into full production immediately, but this was impossible because of the legal battle over water rights. As long as water could not be diverted or compensating works constructed, the company could not produce the power necessary to meet their financial obligations. Loans from Consolidated [illegible], JUNE 30th 19[illegible]

Real Estate & Franchises		
Bonds for Contracts & Franchises	655 000 00	
Stock for Franchises	405 000 00	
Bond Commission	4[illegible] 000 00	
Cash Expenditures	86 776 23	1 668 776 23
Canal Construction	2 386 058 52	
Canal Right of Way	26 427 04	
Movable Dam	222 029 43	2 634 514 99
Power Building	1 028 835 32	
Equipment	54 162 96	
Tools & Machinery	345 436 99	1 428 435 27
Real Estate	145 547 70	
Taxes	39 700 49	
Land Improvement	174 95	185 423 14
East Dock	44 888 03	
West Dock	24 366 93	69 254 96
Miscellaneous		
Engineering & Draughting	93 252 42	
Incidentals	50 403 18	
Legal Expenses	29 014 04	
Office Expenses & Supplies	13 616 03	
Salaries of Gen'l. Office Clerks	37 407 84	
Tel. & Tel. Expenses	2 129 77	
Interest and Discount	675 558 03	
Legislative Expenses	17 277 49	
Insurance - Fire	1 057 79	
Insurance - Accident	1 127 98	
Old T & C Accounts	805 18	
Machine Shop	573 08	
Electric Transmission Line	19 127 92	
Promotion New Industries	462 44	
Administrative Expenses	6 821 87	948 730 06
Total		6 955 134 65
Credits		
Electric Power Earnings	1 500 00	
[illegible] Wages	------	
Misc. Discount	13	1 500 13
Grand Total		6 953 634 52

([illegible])

had kept the company afloat through the construction period and it was apparent that further loans would have to be arranged to keep the company from bankruptcy until the legal problems were settled. In late 1902, however, Consolidated was beginning to have financial problems of its own.

In 1899 the Consolidated Lake Superior Company had been incorporated with a capital of 20 million dollars, but in the short period of four years it had grown to a colossus with a capital of 117 million dollars and an annual budget that at one time exceeded that of the Province of Ontario.[71] It is easy to see that although it was a huge undertaking for its time, the Michigan canal and power houses were only a minor part of Clergue's industrial empire by 1903. A comprehensive documentation of this meteoric rise from the humble beginnings in 1895 is beyond the scope of this report, but since the MLSPC was intricately tied to the parent company and Clergue's manipulations, an examination of the history of the Consolidated Lake Superior Company is necessary.

The formation of the Consolidated Lake Superior Company and the sale of its stock gave Clergue the vehicle and money needed to develop and expand the nucleus of industries which existed in 1898 (See Table 12). There is no question that expansion was desirable, because the company's holdings in 1898 with the exception of the pulp mill were undeveloped and widely scattered. Investment was needed to finish projects already started, such as the Michigan canal: to tap untouched resources, such as the iron mine; and to tie the scattered projects together with transportation links. It is important to remember that Northern Ontario at this time was a wilderness and all facilities necessary for industry had to be developed from scratch. The question was, how to undertake development?

Clergue's answer was that all his contemplated projects would be very profitable and therefore should be kept within the company and that all the projects could be better managed if kept under the control of one large conglomerate. The formation of this conglomerate would, of course, take enormous capital, but the fortunes of the syndicate which was backing Clergue were estimated to be as high as forty million dollars.[72] Clergue, whose ability to talk these financiers into supporting his schemes, has already been described. With this financial backing he constantly expand-ded his operations in Algoma. Whenever a resource was needed, a new company was formed to provide it; whenever an outlet was needed for a by-product, another company was formed to use it; whenever transportation was needed for raw materials or finished products a railroad was built or shipping company established. So went the development, and each new industry provided impetus for another (See Table 13).

[illegible]

- Lake Superior Power Company (Formerly Ontario and Sault Ste. Marie Water, Light and Power Company)
  - Tagona Water and Light Company
  - Sault Ste. Marie Pulp and Paper Company

THE CLERGUE COMPANIES IN 1898

- Lake Superior Power Company
  - Tagona Water and Light Company
  - Sault Ste. Marie Pulp and Paper Company
  - Consolidated Lake Superior Company (formerly American Lake Superior Power Company)
  - Michigan Lake Superior Power Company

(History of the Consolidated Lake Superior Company, p 25A)

Table 13:

HOLDINGS OF CONSOLIDATED LAKE SUPERIOR COMPANY - 1903

(Capitalization in Parentheses)

Consolidated Lake Superior Company
($117,000,000)

- Lake Superior Land Company ($200,000)
- Tagona Water and Light Company ($200,000)
- Sault Ste. Marie Pulp and Paper Company (Algoma Iron Works) ($2,000,000)
- International Transit Company ($150,000)
- Trans-St. Mary's Traction Company ($400,000)
- Ontario Hudson Bay and Western Railway Company
- Manitoulin and North Shore Railway Company ($1,[illegible],000)
- Michigan Lake Superior Power Company ($500,000)
  - Sault Ste. Marie Terminal Railway Company ($100,000)
- Algoma Commercial Company ($10,000,000)
- Algoma Steel Company Ltd. ($20,000,000)
  - Lake Superior Power Company ($2,000,000)
- Ontario Lake Superior Company ($24,000,000)
- British America Express Company ($100,000)
- Pacific and Atlantic Railway Company
- Algoma Central and Hudson Bay Railway Company ($[illegible],000,000)

(History of the Consolidated Lake Superior Company)

This continual expansion created an aura of prosperity but in retrospect it is apparent that much of the prosperity was dependent upon the continual infusion of investment capital rather than profits made by the emerging companies. Much of the business of the companies was with one another which gave an impression of activity but did not provide a return on investments. Profits made by the companies which had reached the production stage with sales to outside consumers were plowed into new developments rather than used to provide working capital for existing operations.[73]

In January of 1902, the Board of Directors of Consolidated began to show concern over the shortage of working capital, and a policy of closer control over the expenditures of the subsidiaries was called for. Essentially this meant closer control over Clergue's constant expansion. By this time the allied companies had become so many in number and their holdings so diverse that the Executive Committee of Consolidated admitted they lacked sufficient knowledge of the company's operations "to enable it to intelligently discharge its duties." Therefore they ordered President Edward Douglas to prepare complete financial statements showing the exact income of each individual company.[74]

The reason for the Executive Committee's ignorance was that even though Consolidated's main office was in Philadelphia, actual management of the companies was conducted by Clergue from offices in the Sault. The main office did little else than arrange financing while the bulk of actual company business was done in a place far removed from the scrutiny of the company officers. Edward Douglas was the main link between Philadelphia and the Sault, but he seemed to have extreme confidence in Clergue and did little to temper the free-wheeling style that Clergue exhibited as General Manager. While Clergue was extremely successful in establishing new enterprises, he gave little thought to their operation once they were under way.[75] The result was that most of the companies were not profitable because of poor management.

Douglas's subsequent report to the Directors showed that Consolidated was indeed in financial trouble and stated that an additional infusion of $3,000,000 would be necessary to keep the company going, even if all new construction was halted. The Board of Directors ordered all construction stopped except the most necessary.[76] Fortunately, the Michigan canal was nearing completion by this time and escaped the cut. It is perhaps significant that the Michigan canal which cost so much and had not provided any revenues exemplified the plight of Consolidated. Its grand opening signified the end of expansion for Clergue and the beginning of attempts to save the entire Consolidated Company from financial disintegration.

In November of 1902 the company began negotiations for the loan of three million dollars that Douglas had cited as necessary to keep operations going.[77] Word of the plight of the company apparently leaked out and as a result the Consolidated stock which had been weak for some time fell from \$19.50 to \$9.25 on the stock exchange.[78] This was, of course, exactly the situation the Board of Directors was trying to avoid, for now the loan needed would be harder to obtain. After a short delay, however, a loan was arranged with the Speyer Company of New York for \$3,500,000. The loan carried with it the stipulation that Speyer representatives would supervise its use, the Speyer would have the right to replace any or all of the directors with its own nominees and that Speyer would have control of all Consolidated securities. As harsh as these terms were the company had no choice but to accept.[79]

The Speyer takeover of Consolidated meant the entire change of company policy from that of expansion to that of fiscal conservatism and retrenchment. Clergue remained as Vice President, General Manager, and Director of the company but shortly found that Speyer control meant an end to his direction of the company's future. His extravagence and tendency to ignore the Speyer policies led to his resignation of all company positions by April 13, 1903.[80] Since E.V. Douglas had resinged as President during the crisis of the preceding fall, this meant that a completely new set of company officers was in charge.

The Speyer attempts to save the company, however, ended in failure. The period from April to August of 1903 were filled with complex financial and structural reorganization but when a necessary bond issue failed on August 27, there was nothing more that could be done. On September 17, 1903, with no money to meet operating expenses and payrolls, all operations with the exception of utilities were shut down. The Speyer Company foreclosed on their loan and one of their representatives, Benjamin Fackenthal, was appointed receiver of all the Consolidated properties including the MLSPC.[81]

The shutdown of the vast industries Clergue had created could not be done, however, without consequence. Employees who depended on the company for their livelyhoods and who had not been paid up to date converged on Sault Ste. Marie, Ontario, and a riot ensued. The Ontario and Canadian governments saw the plight of the town and the company and decided the industries that had been established there could not be allowed to disintegrate. Clergue was also loathe to let his greatest creation turn into a disaster. A Reorganization Committee was formed with Clergue at its head and negotiations were held with the Provincial Government to find some way of saving the enterprise from disintegration.

Arguments in the Ontario legislature were heated over whether or not to support the company but the decision was swayed in the company's favor because many Canadians had the impression that the company's financial problems had been caused by American industrial interests trying to eliminate Canadian competition, and because the abandonment of all the Consolidated industries would be a major economic blow the Province.[82]

The Province agreed to guarantee a loan of $2,000,000 and in other ways facilitate rehabilitation of the company. The Province, however, insisted that the president of the new company be a well known Canadian industrialist or financier, and to this effect, C.D. Warren, President of the Traders Bank of Canada, was chosen.[83]

On May 19, 1904, the Lake Superior Corporation was incorporated with capital of $40,000,000 and replaced the ill-fated Consolidated Lake Superior Company. This new company marked the end of the Philadelphia syndicate's control, but since Clergue had played such a major role in negotiations and reorganization he was retained as a director and advisor of the new company.[84] Although he remained in the Sault until 1911, Clergue was never again allowed to direct the company operations.

The Reorganization had completely refinanced the company and arrangements were made to pay off the Speyer loans and other debts. Under the new finance agreements the United States Mortgage and Trust Company became trustee for the company's bonds and C.D. Warren was named receiver for the mortgage on the company. For many years the approval of the United States Mortgage and Trust Company was necessary for any sale or disbursement on capital accounts.[85] By November 1904, reorganization of the company was complete and C.D. Warren began to try to revive the empire Clergue had built.

At this point the history of the Michigan Lake Superior Power Company continues, but it no longer is concerned with the Consolidated Lake Superior Company or its founder, Francis Hector Clergue. Without Clergue or the industrial giant he created, however, the Sault power house and canal would probably be much shorter. Why did Consolidated fail and force Clergue to leave his work in the two Saults unfinished? Donald Eldon gives us the best probable synopsis:

> Francis Clergue's greatest project failed, as all his projects had failed, because he did not know where to stop, and because he had an ability to inspire in his suppliers of capital a similarly overoptimistic attitude toward projects which he initiated. He was always a little too far ahead of his time. In his tremendous confidence and vision, Clergue illustrates what is at once the great strength and weakness of the entrepreneurial genius; the same irresistible driving power that injects a new innovation into an ordered economic situation expands the initial enterprise until it bursts.[86]

It wasn't until 1913 that the Michigan Lake Superior overcame its financial difficulties, and for Clergue's Canadian industries it took even longer. Even though Consolidated's reorganization into the Lake Superior Corporation promised new beginnings, it paid no dividends on its $40 million of capital stock and went into receivership in 1932. In 1935 it was again reorganized into the Algoma Steel Corporation and finally became successful.[87]

In these years of problems Francis Clergue was at times cursed for the problems he had caused and the fortunes he had lost. While the investors who had backed him probably never forgave him, the people of the two Saults realized that without Clergue they would probably have remained small, economically undeveloped towns. In 1937 at the age of 81, Clergue was summoned back to Sault Ste. Marie to attend a celebration in his honor.[88] At a dinner held in conjunction with that celebration portraits of Clergue were unveiled which now hang in places of honor in both Sault, Michigan and in Sault, Ontario.

Clergue did not die a pauper nor did he die exceedingly rich. As Allan Sullivan said of Clergue:

> His own opportunities for making fortunes had been numerous, but it was against his nature to advantage himself by coming developments in which he was personally involved. Never was there any attempt to transfer money from the pockets of others to his own, rather he aspired to benefit all men by increasing the natural wealth of the country.[89]

Upon leaving Sault Ste. Marie Clergue continued his entrepreneurial projects which included promoting railways in Northern Canada and selling munitions to the Russians during World War I. These ventures, if not totally successful, were enough to provide him with a comfortable life in Montreal where he died in 1939 at the age of 83.[90]

MARKING TIME

C.D. Warren as president of the new Lake Superior Corporation and as receiver of all the properties of that company for the United States Mortgage and Trust Company, was not immediately able to concentrate his attentions on the enormous problems of the MLSPC. When he was able to review the company's situation he must have wondered if the MLSPC could be saved. The company owed almost six million dollars but no additional revenues could be produced until the following conditions were fulfilled: 1) The legal matter of ownership of the St. Marys Rapids would have to be settled. 2) The compensating works would have to be completed. 3) Repairs and modifications in the power house foundation would have to be made. 4) The remaining turbines, generators, and electrical connections would have to be installed. 5) Industries to lease power could be found.

These were problems which did not have immediate solutions. The legal matter of riparian ownership was in the courts and Warren could only await the outcome. The compensating works could not be completed until the court battle was over. Repairs and completion could be started on the power house but that would take money. The MLSPC was making some money from the Carbide contract but since the company only had the physical capacity to use 8,500 cubic feet of water, these revenues were not even enough to pay the interest on the company's mortages.

In February of 1905, L.H. Davis, who had replaced H. von Schon as Chief Engineer of the Michigan plant in October of 1903, sent a report to Warren on the estimated cost of completing the plant and the estimated earnings of the company. Davis reported that the cost of completing the plant excluding power house repairs and extending the compensating works would be over half a million dollars. He estimated annual revenue under existing conditions at about $75,000 and pointed out that without making repairs to the power house and extending the compensating works it would be impossible to increase earnings to any material extent.[91]

Davis' estimates on revenues were optimistic if the plant could be put into total operation, and those estimates were based on a lease rate of $20 per horse power per annum whereas the contract with Union Carbide Company for 20,000 horse power was only for $10 per horse power. Davis also did not have any realistic estimates on the costs of power house repairs and completing the compensating works which could bring the total additional investment needed to as much as two million dollars. The financial outlook, in spite of optimism on Davis' part, was not good.

Warren decided that his first step in putting the company into full operation would have to be finding additional funds which meant obtaining another bond issue. Under the conditions of receivership he had to have approval of the United States Mortgage and Trust Company to offer bonds which complicated the process. To further complicate matters, the MLSPC was now in receivership to two mortgages. In the financial chaos of 1903, the MLSPC had defaulted on that year's payment on the 1st mortgage bonds, and on May 4, 1904, the Provident Loan and Trust Company had foreclosed as trustee for the 1st mortgage bondholders.[92] Now any capital expenditures and bond issues not only had to be sanctioned by the U.S. Mortgage and Trust Company but also by the 1st mortgage bondholders.

In January of 1905 Warren started negotiations with both mortgage holders to get permission to issue receiver's certificates of $500,000. Permission from the U.S. Mortgage and Trust Company was easily obtained since Warren was President of the Lake Superior Corporation which held the MLSPC stock. The 1st mortgage bondholders were reluctant to allow any further expenditure of money or issuance of bonds, however, without having some representation in the company.[93] To this effect Clarence M. Brown was named co-receiver of the MLSPC and represented the 1st mortgage bondholders.[94] The company now had two managers, each representing different owners.

After the appointment of Brown, the 1st mortgage bondholders agreed to the issuance of the receiver's certificates, and in August of 1906 final permission was given by the courts for their sale.[95] The Receivers soon found, however, that investors were not interested in a company having as many problems as the MLSPC. Even if buyers were found the company began to doubt if starting repairs was a good idea. They recognized that repairs would be futile since they couldn't increase power production until litigation on water rights was decided. They also realized that $500,000 would not be enough to put the plant into full production even if they could sell the certificates. These observations, couples with doubts over whether or not the plant would be profitable enough to pay off any further large expenditures of money until the water rights issue was settled.[96]

In January of 1905 the circuit court of the United States found in favor of William Chandler in the case, "The United States vs the Chandler-Dunbar Water Power Company."[97] Although the case was being appealed, this decision was ominous for the MLSPC. In view of the decision, the War Department gave Chandler the permit needed for expansion of the power plant in the rapids and for diversion of a large portion of the water in the rapids. If Chandler did develop the plant to its total capacity it not only meant that there would not be enough water left for the MLSPC canal, but that Chandler would be able to sell power at a much lower rate than the MLSPC ever could.

It was estimated that the Chandler-Dunbar development would cost $90 per horse power as opposed to a cost of $200 per horse power for the MLSPC plant when fully equipped. Upon completion the Chandler-Dunbar company could sell at a profit its entire output at prices which to the MLSPC's only hope was a reversal of the circuit court's decision or the condemnation of the Chandler property in the rapids by the United States for the purpose of lock construction.

In 1905 another participant in the riparian issue had entered the scene, the International Waterways Commission. Although the idea of an international commission had been suggested as early as 1895, the United States had made no attempt to formulate one until 1902.[99] The Board of Engineers investigating the MLSPC in 1898-99 had suggested the formation of a board to deal with unsettled problems of the St. Marys Rapids in their report to the Secretary of War, and the hearings in the Rivers and Harbors Committee from 1900 to 1902 on the MLSPC project indicated the need for such a commission. It can be assumed the problems in the St. Marys Rapids were one of the main reasons for the formation of the International Waterways Commission, since Congressional authorization was given for the Commission in the same Rivers and Harbors Act which authorized the diversion of water for the MLSPC. The Canadian Government did not act until 1905 but at that time passed legislation authorizing the formation of their half of the commission.[100]

One of the first actions of the new commission was to formulate regulations governing the use of water on international boundary rivers. Section 4 of these regulations dealt with the St. Marys River which specified that no future diversion or construction could be undertaken until plans were submitted to the Commission for consideration and recommendation. The section also specified that the MLSPC could divert no more than 8,500 cubic feet of water per second until plans for remedial works were submitted and reported on.[101]

In the Commission's first official report in May 1906, they stated:

> Upon the organization of the International Waterways Commission it found the most pressing matter coming within its jurisdiction was the regulation of the use by private corporations of the waters of the St. Marys River in connection with the control of those waters for the protection of navigation at present and in the future . . . The extent of commerce on the Great Lakes is well illustrated by official statistics of the amount of freight which passed the locks at Sault Ste. Marie during the season of navigation of 1905, which amounted to more than forty-four million net tons. In other words, by transportating the Lake Superior freight on the great lakes $116,000,000 were saved in 1905, to the producers of raw materials, the manufacturer, and the customer, and the saving to manufacturers has made it possible for them to supply the home markets and compete in those of foreign countires . . . The growth of commerce upon the Great Lakes in the past few years, and its prospective immense increase in the future, has convinced the commission that steps should be taken, not merely to preserve the lake levels, but to retain absolute control of all waters which go to maintain those levels, and of all lands which may be useful or necessary, at present or in the future, to increase navigation facilities.[102]

This report of the IWC must have been well received by the MLSPC for if the IWC's recommendation of retaining absolute control of all waters and all lands necessary to increase navigation facilities was followed, it meant the condemnation of the Chandler properties by Congress even if Chandler won the court case. They knew that new lock facilities were needed and as time wenty by this need would increase and with it the pressure on the government to secure public ownership of the Chandler property for the construction of those locks. When the government had secured ownership the MLSPC could proceed with the construction of the compensating works and diversion of water as provided for under the Rivers and Harbors Act of 1902. Thus the MLSPC was "marking time" until government control became a fact.

While the delay caused by the appeal of the Chandler-Dunbar case was acceptable to the MLSPC it was particulary exasperating for the citizens of Sault, Michigan. They had been anticipating the development of water power since the canal was first begun in 1888 and had thought the grand opening in October of 1902 signified the realization of their dreams of prosperity. Now although the canal and power house seemed ready to produce, they remained inoperative. In 1902 public opinion had been strongly behind the MLSPC and Chandler was seen as the villain who delayed the canal's full use by filing suit to stop diversion. With the filing of the countersuit by the MLSPC through the government that opinion began to slowly shift against the company. When Chandler promised a large power development and began work on it in 1905, public opinion had shifted into Chandler's favor.

The citizens looked upon the circuit court's decision as a mandate for the MLSPC to acknowledge Chandler's claim to riparian rights and come to a settlement with him so that the water power could finally be fully developed by both parties. An article in the Sault Evening News in November of 1905 gives a good summation of the local opinion of the time:

> There has been for some time talk among the people of the Soo that we are not getting our dues from the Michigan Lake Superior Power Company in the completion of the canal and in the fulfillment of certain pledges and promises made by that company. The people would not like it to appear that they are dissatisfied but they feel that the building of the canal was imposed burdens upon them which are hard to bear and they would like some encouragement from the company to help them bear these burdens. We understand that the company has been up against it in many ways, but they have directed their energies toward developing the interests in the Canadian Soo while the enterprise on this side of the river is in status quo, not a cent having been expended here in some years.[103]

In the same month a Chamber of Commerce meeting was held to discuss the MLSPC situation and what the city could do to force action by the company. The result of the meeting was the threat of the repeal of the specific tax law that had been passed by the Michigan legislature in 1899 at the request of city of Sault Ste. Marie.[104] The city ordinance of 1898 had stated that the city would secure a special tax of $5,000 per annum in lieu of the normal property tax in order to case the company's financial burden of construction costs. In their enthusiasm over having the canal finished, the city had lobbied the legislature and the specific tax law had been passed. Now, if the company did not take steps to put the canal into full use the citizens threatened to have the specific tax law repealed. This threat carried leverage because the normal tax on the MLSPC property could run as high as $75,000, an additional financial burden the company would find hard to bear.

While the initial purpose of the Chamber of Commerce meeting had only been to spur action by the company it began a strong movement in the city and county against the company. The coming year was an election year and candidates were more than willing to seize any issue which stirred the public conscience. As the political campaigns gathered momentum in 1906 politicians lined up into pro and anti MLSPC factions, but with pro-company stands becoming more and more like political suicide.

Although the company was in a financial and legal position which kept it from putting the canal into immediate use, the citizens cannot be blamed for complaining. They had legitimate cause. Investors in the first canal company had lost close to $200,000 when that company went bankrupt, an investment which accrued to the MLSPC when they acquired the canal for $68,000. Estimates on other city expenses due to the canal were $100,000 for bridges, $150,000 to change the site of the city pumping station, $40,000 to modify the sewer system, and $20,000 for changes in streets, alleys, sidewalks and water pipes. In addition, the company had the advantage of the specific tax which represented a tax loss of at least $150,000 to the city.[105] These figures added up to over $650,000 which the city had expended on the canal plus all the inconvenience caused.

The call for the repeal of the specific tax began as a threat to spur action, but became a crusade against the specific tax itself as unfair to taxpayers who stood to gain nothing from the power plant's completion. The farmers of Chippewa County who were paying approximately half of the county taxes saw the repeal of the specific tax as a means of relieving their tax burden.[106] The specific tax issue continued to play a part in local politics until 1909 when a bill was finally passed for its repeal. In the meantime it was brought up again and again as a lever in affecting MLSPC policy.

The Receivers and management of the MLSPC saw much of the agitation in Sault, Michigan as the result of the Chandler-Dunbar interests in the city. The "Evening News" was owned by people sympathetic to the Chandler company and as a result carried many articles and editorials which berated the MLSPC and the Lake Superior Corporation which actually managed the company.[107] To counteract this adverse publicity and to try to prevent the repeal of the specific tax, the company began to circulate answers to charges made against the company.

In response to the charges that the Lake Superior Corporation had spent money on their Canadian operations and ignored the Michigan company, they cited the fact that many of their Canadian plants were still inoperative and yet $225,000 had been spent in paying off MLSPC construction debts. They went on to say that the MLSPC was not an asset to the Lake Superior

Corporation and that "there is not a company on the face of the earth, that would accept our water power plant, power house and all as a gift subject to the present encumbrances."[108] The charges that the company had been ignoring the Michigan company in favor of the Canadian companies was particularly exasperating because many Canadians were accusing the Lake Superior Corporation of being an American company trying to rule a Canadian town.[109]

The company also pointed out that the city had benefited much from the money spent during the construction of the plant, that in addition to the specific tax the company paid $5,000 a year on lands which were not included in the specific tax legislation, and that the company paid at least $30,000 a year on payrolls in Sault, Michigan.

In May, 1907, the receivers decided to try to negotiate with the Chandler-Dunbar Company for the rights to divert water into the canal and erect compensating gates. This decision was probably affected by three factors. 1) If the MLSPC appeared to be trying to reach a settlement it might forestall the repeal of the specific tax law. 2) In May of 1907 the Chandler-Dunbar Company was nearing completion of the extension of their head race in the rapids but they had not yet built the power facilities necessary to use the additional water which the extension made possible. An agreement had to be reached before the Chandler Company finished these works which would use water needed by the MLSPC. 3) In early 1907 the appellate court had affirmed the circuit court decision of ownership of the rapids in favor of Chandler. If the appeal to the Supreme Court failed and the Government did not condemn Chandler's property and water rights, then an agreement with the Chandler Company could be inevitable. Since records of management decisions and relations between the Lake Superior Corporation and the 1st mortgage bondholders are not available, it is not possible to ascertain the rationale for many of the company's decisions of this time. It is safe to say, however, that the MLSPC saw negotiations with the Chandler-Dunbar Company as a move that could only help the company.

Starting on May 24, 1907, the MLSPC entered into protracted negotiations with the Chandler Company lasting until March of 1908. The negotiations were hampered by the animosity which had evolved between the two companies, the case pending in court inititated by the MLSPC against the Chandler Company, the uncertainty of the international boundary in the rapids and of the international division of waters, and the uncertainty of what the government action would regarding the use of the St. Marys River. The proposals and counterproposals for settlement were very detailed, but the two parties were never able to reach a position agreeable to both.[110] It seems that neither side was really ready to settle until the court case had been decided and the government had made some definite move.

The MLSPC and Chandler-Dunbar Company negotiations were held concurrently with other negotiations concerning the St. Marys Rapids. These were between the War Department and the Chandler Company over the acquisition of land for the improvement of ship lock facilities. The 1902 Rivers and Harbors Bill which had provided for the diversion of water for the MLSPC and the formation of the International Waterways Commission had also provided for the enlargement of the canal leading to the locks. In 1905 another bill had passed for improvement in lock facilities and $1,200,000 had been appropriated by Congress for this purpose.[111] These improvements had been forestalled by the pending court case against Chandler much to the aggravation of the Rivers and Harbors Committee and the Lakes Carriers Association.

In January of 1905 Chandler had offered to sell the government the land needed and in March of 1906 the government had actually negotiated with him to obtain that land. It was decided that buying land from Chandler, however, would acknowledge his ownership and be prejudicial to the pending court case.[112] By 1907 the need for increased and improved lock facilities was so great that Congress appropriated $6,200,000 for that purpose in the Rivers and Harbors Act of that year. This Act included the Frye amendment which authorized the Secretary of War to enter negotiations for the acquisition of land and, if negotiations failed, to condemn the land while denying that any such action was acknowledgement of Chandler's ownership.[113]

Under the provisions of the Frye amendment the War Department began negotiations but Chandler refused to settle without acknowledgement that he was the legal owner of the land in question. In February of 1908 the War Department announced that negotiations had failed and they were ready to proceed with condemnation. They were advised by the U.S. Department of Justice, however, that the Frye amendment would not stand up in court and that condemnation could only proceed when the property rights issued was ruled on.[114]

The failure of the Frye amendment forced the Rivers and Harbors Committee to consider new legislation that would obtain the land from Chandler. These new hearings were opened in April of 1908 with the warning from Chairman Burton that the committee meant business and that the conclusion of the matter would be some action guaranteeing the construction of the new lock and canal.[115] The hearings initially went in favor of Chandler with the committee backing the Young Bill. This bill was based on an offer of the Chandler-Dunbar Company to transfer land needed for locks improvement free of charge in exchange for the Government's acknowledgement of the Company's perpetual right to the rapids and the use of its water not needed for navigation purposes. The government, however, would have to pay the cost of moving the Chandler-Dunbar plant out into the rapids to a point where it would be beyond any possible future interference with locks improvements. Chairman Burton, however, was so opposed to this bill that he let the session close without reporting any proposal to Congress for legislation.[116]

On April 20, 1908, while hearings on the Young Bill were being conducted in committee, the Supreme Court handed down a decision on "The United States vs the Chandler-Dunbar Water Power Company." It affirmed the rulings of the two lower courts stating that "A patent from the United States, invalid when made, after five years without attack, must be deemed -- as though it were valid when issued," and that, "the land granted as bounded by the St. Marys River, carries with it the title to small unsurveyed islands on the American side of the international boundary line, where under the laws of the state, a grant of land bounded by a stream, carries with it the bed of the stream to the center of the thread."[117]

Although this decision was in favor of Chandler, public and government opinion had turned against that company for its unwillingness to come to terms on any conditions other than its own. The failure of the Young Bill hearings had brought the Rivers and Harbors Committee to the decision to condemn all the Chandler property in the rapids including the water rights (See HAER photo #1 for a view of the rapids at the time of condemnation).

In 1909 Rivers and Harbors Act passed on March 3, contained two sections designed to give the government complete control of the St. Marys River. Section 11 provided for the condemnation of all private land in the rapids to take effect no later than January 1, 1911, and for a treaty to be made with the Canadian Government for the maintenance of lake levels by the construction of controlling works. Section 12 provided that the water power in excess of the needs of navigation could be developed for use by the United States or leased by the Secretary of War for a reasonable compensation.[119]

On September 27, 1909, the Secretary of War filed notice of condemnation with the register of deeds, Chippewa County, in accordance with the recent Act of Congress.[120] Due to delays in the preparation of the condemnation suit by Government attorneys, however, hearings on the case did not begin until February of 1911, past the deadline set by Congress for condemnation to be concluded.[121] In the hearings in the circuit court the Chandler-Dunbar Company claimed a value of 7 to 8 million dollars for its property on the basis of the potential value of water power. The court, however, set the amount to be paid at $652,312 which included the cost of improvements on the property. The Edison Sault Electric Company was awarded $300,000 for its plant on the Chandler property and granted a lease so it could provide uninterrupted electric service to the city.[122]

The Chandler-Company, upset at the disparity between what they thought they should have received and the actual award by the circuit court, appealed the decision to the Supreme Court. This proved to be a mistake, for on June 21, 1913, the Supreme Court ruled that since the Government was condemning the land and not the inherent riparian flow of the stream it needed to award only for the value of the land. The award to the Chandler Company was consequently reduced from $652,312 to $65,450.[123] With this decision it almost seemed as though the Government was retaliating for the dubious method in which Chandler had secured the land, the low price he paid for it, and the delay he had caused in the development of the rapids for navigation and power purposes.

With the passage of the Rivers and Harbors Act by Congress and the notification of condemnation of the Chandler-Dunbar properties in 1909, the MLSPC's long battle with that company was finally over. With the ownership of the rapids settled the MLSPC now had to work out an agreement with the Government on the use of water and the erection of compensating works. Under the act of 1902, the company still had the right to divert water into the canal, but the act of 1909 provided for any diversion of water to be under a lease arrangement. Before any additional water was diverted, the compensating works would have to be expanded.

Clarence Brown immediately inquired of General Marshall, Chief of Engineers, as to when negotiations could begin for a water lease and for extension of the compensating works. Marshall's answer was disheartening for he intimated that no lease arrangements could be made until the amount of the compensation for the Chandler property had been determined upon by the courts.[124] Although preliminary discussions began in 1911 on possible lease conditions, no definite action was taken until the final condemnation awards were made by the Supreme Court in June of 1913. Thus, although indirectly, the Chandler-Dunbar Company caused another four year delay in the completion of the MLSPC power complex. These years, however, were not wasted but were used in the much needed reorganization of the MLSPC which in its present financial condition would be unable to undertake the added expense of power house repairs and completion of this compensating works.

The delay caused by the water rights issue from 1902 to 1913 was indeed unfortunate for the MLSPC. The delay represented eleven years of lost production putting the company financially further into the red, and prevented them from obtaining additional capital needed to complete the plant. One fortunate aspect of the delay, however, was that it gave the company engineers and consulting engineers time to study in depth the defects in the construction of the power house forebay and foundation. These years of exasperation and experimentation resulted in solutions which have stood the supreme test of time.

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Even before the grand opening on October 25, 1902, there were intimations of trouble at the power house. On October 22, during the preliminary tests on the power canal and power house, a slight deflection of the center of the power house towards the river was detected at a head of only 7 feet. As the head was increased to 12 and then to almost 15 feet in the next few days the deflection increased to 1.25 inches.[1] (See HAER drawing, sheet 7 of 8)

Water was drained out of the canal shortly after the opening celebrations and the building inspected. A slight crack was found at the east abutment, and a slight opening was discovered between the building's forebay wall and the timbers of the forebay apron in the center. These flaws were repaired and observations of building alignment resumed in early November when the canal was refilled. As the head was increased slowly from 3.5 to 16.5 feet, the highest attainable at the time through the sluice in the upper intake coffer dam, the deflection steadily increased to almost 2 inches in the center. There was still no deflection at the west abutment, but the east end had moved a half inch. The head was lowered to about 13.5 feet and daily observations continued.[2]

Fearing for the stability of the structure von Schon consulted with Noble in late November or early December 1902. Following this conference von Schon wrote to Clergue. He acknowledged that there was no way to predict the limit of deflection, or just how much deflection the structure could take and remain intact. But, he declared, the review he and Noble had made of the steps taken in construction to insure stability against sliding showed a large safety factor. He postulated that the deflection detected was probably due to the compression of the material which sustained the pile foundation and should not cause too much concern. To arrest the movement of the east abutment he recommended enlarging the east power house dock. For the central deflection von Schon suggested placing some submerged stone buttresses against the downstream face, if conditions persisted.[3]

The head at the power house was maintained at 13.5 feet through much of November and all of December. But the defection increased from under 2 inches to around 2.25 inches. The level of the water was gradually raised from January 5 to February 7, 1903, in further tests of the power house's integrity. The deflection by February 7 had increased to 3 inches at a 16.5 foot head.[4]

An already troubled situation was exacerbated when, on February 8, 1903, a massive washout under the foundations of the power house forced the plant, which had not even gotten past the testing stage, to completely shut down. At about 4 a.m., Sunday morning, February 8, an ice fisherman on the St. Mary's about 300 feet in front of the power house noticed that the usually crystal-clear water was so muddy that it was impossible to see into it. He reported this to the watchman at the power house, who notified von Schon. Suspecting that this phenomenon was caused by water under pressure rushing out of the forebay under the power house foundation and churning up the silt in the river bottom, von Schon ordered the headgates shut down and the canal drained. Examination by divers began immediately.

After the water was drained from the canal, inspection disclosed no serious damage to the power house, but a massive cavern had been washed out from beneath the foundations, a cavern approximately 100 feet long, 120 feet wide, and an average of 10 feet deep. The washout appeared to have begun at penstock 50. At this point a small creek had once emptied into the river. (See HAER drawing, sheet 7 of 8) One of the reasons the power house had been moved 100 feet south of its original location had been because this creek had cut too deeply through the bed of clay on which the foundations were to rest. Even at the new location remedial work had been necessary. The silt deposited where the creek had cut into the clay was excavated and the area refilled with clay puddle. These precautions, however, were clearly insufficient. Some gravel, sand, or silt strata must have remained between the natural clay bed and the puddled area. Von Schon speculated that forebay water, under pressure, had followed this strata, washed it out, and then begun to erode and wash out the clay puddle and natural clay bed. The 8-foot deep row of sheet piling driven around the foundations had been designed to protect the clay under the foundations against this type of action, but it failed.[5]

Von Schon immediately had a sheet pile coffer dam driven at least 16 feet deep on the north side of the power house, 2 feet in front of the foundations, extending across the washed out area and 100 feet further on either side. He covered these piles with heavy canvas and dumped coarse gravel on both sides. Inside this sheet piling concrete in bags was laid down by divers. To fill the 3000 cubic yard chasm under the power house he had 7-inch holes drilled through the floors and foundations over the cavern. Coarse gravel was forced through pipes inserted into these holes under pressure from water pumps until the northern half of the washout was a compact mass of coarse gravel. A similar sheet pile dam was also driven 2 feet in front of the upstream edge of the foundation and extended east and west up the entire face of the power house. This portion of the washout was filled in a similar manner to the downstream end, with cement grout forced into the gravel afterwards.[6]

Von Schon's program of repairs was submitted to a consultation board consisting of Noble, Boller, and Samuel Whinery, one of Noble's associates. They visited the site and generally approved of von Schon's plans and actions. They recommended, in addition, that the entire forebay area be planked in a manner similar to the timber section of the canal. Piles on 8 foot centers were to be driven in the region, capped by 12" x 12" timber sills, running perpendicular to the power house. The space between the sills was to be filled with clay, and then the sills were to be covered with 2 layers of 2-inch plank, separated by tar paper. The forebay apron was also strengthened at their recommendation. And, in an attempt to reinforce the power house against sliding, iron straps and braces were used to tie the log sills of the forebay floor to the power house sub-structure at Noble, Boller, and Whinery's recommendation.[7]

The total repair program took much longer than anticipated. Von Schon had estimated to the new president of Consolidated Lake Superior, Cornelius Shields, in early February 1903 that the repairs would cost around $12,000 and be finished by early April.[8] The additional work recommended by the consultant board increased costs and delayed completion.[9] In addition there were problems in securing planking for the forebay.[10] Construction equipment shipped in by rail could not immediately be used because freight charges could not be paid immediately due to the parent company's financial difficulties.[11] As a result, it was not until August 22, 1903, that the plant resumed operations, and the total cost of repairs was not $12,000, but around $180,000.[12]

The early problems with the power house together with the repair cost over-run and the delays encountered in repair completion seem to have destroyed von Schon's credibility with the president of Consolidated Lake Superior. Von Schon was relieved of his duties on October 1, 1903, when the plant passed into receivership along the rest of Consolidated Lake Superior. Boller made some attempt in September 1904 to have the company retain von Schon to direct the hydroplant he had constructed on hearing news that von Schon was contemplating accepting an offer on the Pacific coast. Writing to Shields, he declared:

> Mr. V. Schon stands very high among Hydraulic Engineers, is a man of the highest integrity, thoroughly versed in the Science of Hydraulic Technics . . . The care of these Soo hydraulic properties is a tremendous responsibility, and requires the highest technical skill, and conscientious qualities of character . . . You will find no better man in the Country for the custodianship of these properties than Von Schon . . .[13]

Depsite Boller's financial involvement in the project, hields demurred. He frankly told Boller that in his opinion von Schon was "not an economical man to handle work", pointing to his low estimate of the 1903 repair work. He added that he "very much" questioned his judgement.[14] Von Schon was thus allowed to depart for other jobs.[15]

After the "Soo" plant, von Schon set up a consulting practice in Detroit, specializing in hydraulics. Small to medium size hydroelectric plans were built under his direction at several points over the country, including Mottville, Michigan; Fremont, Ohio; High Bridge, Michigan; and Little Hickman on the Green River in Kentucky. He designed and marketed a hydroelectric plant that placed the generator room within the dam, completely submerged by the overflowing water. He also designed a water supply system for Highland Park, Michigan, where he made his home from 1904 to 1916. Between January 1913 and October 1914 von Schon edited a periodical called the Water Power Chronicle (later Water Chronicle). This periodical folded just after World War I broke out, perhaps because of a pro-German political article which von Schon reprinted in the October 1914 issue.[16] Von Schon also published several editions of a book titled Hydro-electric Practice. During the early part of World War I he served as a writer on military affairs for the Detroit Journal, as well.

He retired from active practice in 1916, though he later did serve as Water Power Commissioner, settling disputes between owners of hydro-plants on the St. Joseph River in Indiana. He died in 1931 at the age of 81.[17]

Von Schon's successor as chief engineer of the Michigan Lake Superior Power Company was Leonard H. Davis. Davis was an 1892 graduate of Lawrence Scientific School, Harvard. In 1893 and 1894 he had completed some graduate work in engineering. Little additional biographical information on Davis could be found. He succeeded von Schon on October 1, 1903, as chief engineer of the Michigan Lake Superior Power Company and became on July 1, 1910, Chief Engineer and General Manager of the company.

Hope that von Schon's 1903 repairs would completely solve the power house problem was quickly proved false. As the canal was refilled, measurements were taken for deflection. With no water in the forebay the building had remained bowed toward the river 2 3/8 inches at its center. As the head was increased the deflection increased. Since a head of 13.5 feet only increased the deflection to 2 5/8 inches, the new chief engineer of the company, L.H. Davis, pushed the head up to 14.4 feet through the winter of 1903-1904, and in the spring increased it to 14.6 with no appreciable change in the building's alignment. He hoped to push it as high as 14.7 feet so that he could secure 500 h.p. per turbine shaft.[18] By the fall of 1904 he had raised the head to 15 feet, at the cost of a slight increase in deflection.[19]

With the plant operating under a head of 15 feet, on September 7, 1904, a new leak was discovered. Muddy water was noticed on the river side of the power house. Davis acting "a Little nervous" inspected the site.[20] Apparently fearing that the leak had been caused by building deflection, he ordered the head lowered 6 inches. Although this leak had been detected before it had become serious, it was still alarming because it was located opposite penstocks 51 and 52, the very point where the big 1903 washout had begun. Oavis immediately sent a diver down into the forebay to locate the cause of the leak. On September 8 he went down himself, and then ordered the head lowered another 6 inches.[21]

Examinations indicated that the forebay apron had separated from the forebay wall by as much as 5/8-inch in some places and that there were numerous other leaks at joints between the forebay planking. The deflection of the building at the higher head (above 14 feet), Davis felt, probably explained the openings. Between September 7 and 14 divers caulked the large crevices in the forebay apron and planking with oakum. The smaller cracks were too numerous, so heavy sail cloth was spread over the forebay floor and nailed down. By September 18 the leak had begun to diminish and by September 26, 1904, it had completely disappeared. Oavis felt that this was probably due to silt deposits making the cloth water tight.[22]

Although the 1904 leak was repaired without shutting down the plant, it was apparent that the 1903 repairs had not solved either of the major power house problems. For the next 6 years forebay leaks were to be a fairly frequent headache at the power house (and one that was not completely remedied until 1926). (See Tables 11 and 12, next two pages). For the next 12 years the company was compelled to restrict its operating head to 14 feet to avoid further endangering the structural integrity of the power house.

Any slim hope there might have been that restricting the head to 14 feet would not only stop further deflection, but prevent forebay leaks as well, was quickly demolished. Muddy water appeared again on the north side of the building as early as February 6, 1905, indicating leakage under the foundations. A diver sent down into the forebay area to locate the source of the problem reported that some of the canvas strips laid the previous year had been displaced. This was corrected and the leak disappeared.[23]

But 6 months later, on July 19, 1905, a leak of considerable proportions broke out close to the earlier leaks. Diver inspection revealed numerous slits in the canvas at the joints of the forebay planking. Caulking with oakum and covering the smaller crevices with lath cut down the amount of mud visible on the north side, but did not completely stop the leak. At 4:45 a.m. on the morning of July 31, 1905, the night watchman reported that the leak was much worse. By 5:20 water was boiling up 6 inches just west of the center of the building on the north side, carrying pebbles up to 1 inch diameter to the surface. Oivers were sent into the forebay to find the source of the leak. They bored holes through the floor and

Table 11:

LEAKS AND SHUTDOWNS FOR REPAIRS, 1903-1926

1903:
February 8 - August 22

1904:
September 7 - September 26

1905:
February 6- February 8
July 19 - August 27
November 29 - December 4

1907:
October 15 - November 9
November 9 - November 20, leak recurred when water readmitted after shutdown

1909:
November 9 - November 22, slight leak continued after water readmitted, and increased
November 28 - December 9, and slight leak after on into 1910

1910:
April 20 - June 9

1917:

1926:
August 13 - December 26,

Note:

Since some leaks persisted at a very low rate for some days after repairs were completed, some of these dates are approximate

Table 15:

Materials Used in Power House Leak Repairs by year, 1903-1926

NB: All figures are approximate; some may be too low because only data on material deposited in forebay is available

	1903	1904	1905	1907	1909	1910	1926
Clay (cu. yds.)	1000(?)			105	1200	1368	299(?)
Cinders (cu. yds.)			72	341	880	80	
Gravel (cu. yds.)	3000(?)		322	704	90	65	7
Sand (cu. yds.)				600			
Concrete (cu. Yds.)	175(?)						1755
Hay (bails)			19	11	8		
Stray (bails)				105	18		
Shavings (bails)				94	12	12	
Manure (sacks)			438				
Oakum (bales)		?		30	15	19	
Tar Paper (rolls)				30	40	160	
Tar (barels)				7		15	
Lumber (bd. ft.) 1000's	84(?)			20	17	32	77

measured the depth of the cavities beneath the planks all across the suspected problem area. Large cavities, some 14 to 21 feet deep, were found opposite penstocks 49 and 50 and 53 and 54. Drilling and soundings made through the foundations indicated some channels 3 feet deep under the power house itself.

Where the cavities were deepest 6 and 12-inch pipes were inserted through holes bored in the planking and a variety of materials -- hay, manure, cinders, gravel -- were forced down my means of smaller pipes rammed into the larger.[24] Filling by pipe began on August 9. By August 25 the leak was nearly repaired. By August 27 there was no evidence of leakage. Filling was continued until the 31st just to be safe.[25]

Plant operations had scarcely returned to normal when, on November 29, 1905, the turbine track man, making his regular inspection of the north side of the building, reported a small leak opposite penstock 54. By the next day water was bubbling up 1 to 2 inches just inside the sheet piling opposite penstock 51. Diver borings in the forebay indicated a cavity 8.5 feet deep in front of penstock 56 under the forebay apron. Other test holes over the area of the 1903 washout indicated cavities of 6 inches to 2 feet. Filling by pipe began almost immediately. By December 4, after passing more hay and gravel through filler pipes into these cavities, leakage was once again stopped.[26]

For almost two years there was no further trouble. But on the afternoon of October 15, 1907, muddy water began to appear on the north water had begun to boil up opposite penstock 64 as well. Davis lowered the head from 14 to 12 feet and sent a diver down to find the source of these leaks. As in 1905 holes wer bored where the diver found indications of leakage and within a few days four 12-inch filler pipes were pushing material into the leaks. By October 19, even with the plant operating under only an 11 foot head, conditions had worsened. Water was boiling up to 1 foot opposite penstock 64. Fearing that this leak, worse than any since 1903, might undermine the structural integrity of the power house measurements were taken for deflection, but no additional slippage was detected. The diver, however, reported that the planking and timber work of the forebay apron in front of penstock 59 had begun to sag, opening considerable seams through which water was flowing at high velocity. Davis ordered the headgates lowered and the canal drained for examination. On the 22nd men began removing the planking from the apron and refilling the material behind it. On October 23 a large cavity was discovered opposite penstocks 57-60. In this area it was also discovered that the sheet piling driven in 1903 had tilted sharply towards the forebay. A pile driver was brought into drive new sheet piling in this area, while filling work continued. To better seal the forebay floor Davis had an additional layer of 2-inch tongue and groove planking installed. (See HAER photos 82 through 84) After a shutdown of approximately

20 days, water was let back into the canal on November 9.[27]

Davis' troubles were not yet over with. When water was let back into the canal a small leak was still detectable on the north side, opposite penstock 59. By the 14th this leak appeared to be worse. Holes 7 inches in diameter were bored through the concrete flooring of the power house and through the foundation to determine the extent of the cavities under the power house in the general area of penstocks 54 through 61. Cavities of from 6 inches to over 2 feet were found. Into these holes the plant superintendent, A.W. Dawson, inserted a 6-inch filler pile, 20 feet long. Inside this pipe he placed a plunger pipe with a piston head 1/16-inch smaller than the 6-inch pipe. Holes were drilled through this piston head and it was covered with a flop valve to prevent suction in the upward lift. Clay was placed in the stationary 6-inch pipe and forced out the lower end by the plunger pipe, which was pushed downward by a large weight. Drilling and filling teams were put to work night and day. At the same time cinders were scattered in the forebay area from a raft in the troubled area. These measures slowed the lead, and by November 20, 1907, it had stopped.[28]

The 1907 repairs held through 1908. In early 1909 the plant was all but shut down. This time, however, it was not due to a forebay leak, but to government orders. Due to abnormally low levels in Lake Superior the Corps of Engineers ordered the Michigan Lake Superior Power Company to close their headgates and cease generating power for any purpose except operating the local street railway. From March 8 to June 12, 1909, the Corps order allowing only a miniscule diversion from the St. Mary's remained in effect. This unavoidable shut down offered an excellent opportunity for inspection of the forebay floor and preventative measures against future leaks. But the financial condition of the company was such that the Receiver, C.M. Brown, ordered Davis to lay off most of the work force for the duration of the shut down and reduce expenses as far as possible.[29] This was a major mistake.

Shortly after noon on November 9, 1909, less than 5 months after the plant had resumed operations, a slight leak was detected opposite penstock 64. The leak rapidly worsened. In a few hours water was boiling up several inches over an area of 8 feet in diameter. Diver examination of the forebay area indicated that the filling under the forebay had washed out badly between penstocks 52 and 64. Since no major disturbance was found in the forebay planking, it was postulated that the problem was probably due to a number of small leaks, rather than one large one. Davis decided to shut the canal down for quick repairs.

The power canal was completely emptied and the forebay pumped out by November 16. Davis and Dawson found that the filling had washed from under the level portion of the forebay floor (as well as from under the apron). The cavities thus created extended over a large area and varied from a few inches in depth to 2.5 feet. Where the cavities were worse the planking was taken up and the clay underneath replaced. Since a good deal of clay had also washed out from under the forebay apron, its planking was removed over a considerable distance for refilling and replanking. At the same time these actions were going on, Davis had a diver distribute bags of cinders on the north side of the power house between the 1903 sheet piling and the foundations. After a shutdown of 13 days, water was readmitted to the canal on November 22.

As the head reached 10 feet there were new indications of mud and water flowing under the foundations on the north side. Since this had occurred after the 1907 work, there was no major concern. The head was raised to 14 feet on November 23, with indications that the leak was diminishing.[30]

From November 23 to November 28 a slight leak persisted. Then on November 28, 1909, the amount of muddy water on the north side began to increase sharply. The head was lowered, and the following day divers were sent down to place filler pipes in the forebay apron once again. The day after that Dawson began drilling holes and ramming clay through the building floor. On December 1 and 2, as a result of the drilling operations within the power house, it was discovered that the cavity opposite penstock 60 was from 4 to 8 feet deep underneath the foundations. Slightly later a 14-foot cavity was discovered opposite penstock 62. Day and night crews operated clay ramming pipes of 5 inches and 6 inches diameter in the power house, while outside the power house other filling pipes were depositing cinders through the forebay apron.[31] By December 9, 1909, the leak had again been reduced to a trickle.[32]

Clay ramming through the power house foundation was continued through December 1909 and on into January and February 1910. Work was concentrated in the area of penstocks 45 to 64, the perpetual problem area from the 1903 washout on, with 2 to 3 holes being drilled per penstock. That further steps would have to be taken became apparent early in 1910. On January 11 a crack appeared in the stone wall between the first and second floors.[33] A few days later, when the clay ramming pipes were placed in holes bored through the foundation at penstocks 57 and 60, water rose inside the pipe, spouting 6 feet above river level, and flooded the generator room floor.[34] Cavities averaging from 1 foot to 2.5 foot were discovered between penstocks 46 to 64.[35] Although the plant was not shut down between late November 1909 and April 1910 it was forced to operate at a lower head because leakage reappeared or increased if the head was raised much over 12.5 to 13 feet.[36]

By the end of 1900 Lake Superior water levels were such that it appeared to Davis that the Corps of Engineers would probably order another shutdown for the plant in the spring of 1910. Davis wrote to the general manager of the Consolidated Great Lakes Corporation, Franz, in late December noting that the shutdown could be used to good advantage in repairing the leak at the power house.[37] By mid-February 1910 the decision to shut the power plant down for leak repairs sometime in the spring had been made.[38] The expected government orders to cease all diversion of Lake Superior waters came on April 20, 1919. Although special permission had been secured to run one turbine to provide power for the local traction company, the decision to completely drain the canal for forebay repairs made it necessary to cut out this unit as well.[39]

Through late April and on through May of 1910 extensive remedial work was carried out. In the power house clay ramming, which had stopped in February, was resumed, with crews working night and day. Outside in the forebay much of the old planking was taken up, the voids beneath the floor filled in with clay, and two new layers of 2-inch planking, separated by tar paper, replaced the old. The forebay apron was also refilled and replanked. To further seal the foundation off from the forebay a deep tranch was dug on both sides of the 1903 sheet piling and refilled with good clay. These repairs were completed in early June. At almost the same time the government authorized resumption of flow in the canal at 54% of normal levels. On June 10, 1910, the hydroplant went back into operation.[40]

Unlike many of the earlier repair jobs on the forebay, the work carried out in 1910 proved to be solid. No leaks were discovered when the water was let back into the canal, and no leaks were to occur for some years to come. It was recognized that these repairs were still temporary and that, sooner or later, additional corrective measures would have to be taken. But the long repsite from the forebay leak problem enjoyed at the power house after 1910 must have been a tremendous relief to all concerned.

The deflection problem, of course, remained throughout this period. From 1904 on standard operating policy at the MLSPC power house was to keep the operating head at around 14 feet in order to avoid further endangering the structure. This precaution enabled the company to indefinitely postpone corrective measures on the deflection. But it was at a cost. Turbine untis which were expected to generate 564 h.p. were at times barely able to produce 400.[41]

The Michigan Lake Superior Power Company was, of course, anxious to remedy the defects in the power house. The problem was how. Between 1903 and 1916 MLSPC and its successor, the Michigan Northern Power Company, called in at least a half dozen consultants or teams of consultants to study the dual problems of deflection and leakage. The array of engineering talent which attacked these problems included some of the most distinguished names in American engineering in the early 20th century.

One of the first to make recommendations on repairing the defective power house was Gustav Lindenthal (1850-1935). Lindenthal was born in Brunn, Moravia, then part of the Austro-Hungarian Empire. He was educated at the Austrian railroad system. Emigrating to American in the mid-1870's, he first found work as a stone mason. By 1890, however, he had gained recognition as one of America's great bridge designers (the steel arch Hell Gate Bridge in New York is considered his greatest work). Since foundation work is the key to a successful bridge, he was a logical person to call in as a consultant on the power house foundations.[42]

Lindenthal visited Sault Ste. Marie in May 1903, while repairs to the first washout were underway, at the request of the company. He was thus able to study the power house foundation and underlying soil conditions in detail and reach some reliable conclusions about what had gone wrong. Lindenthal's report suggests that von Schon and "the Consulting Engineer" (Noble) had erred in assuming that the friction between the concrete foundation and the clay and gravel surface on which it rested would contribute to resistance against sliding. He declared:

> That friction would aid in the resistance of sliding only, if the water would be prevented from getting under the concrete. But with the great hydrostatic pressure from a full canal, that could not safely be expected.[43]

Water seeping under the foundations, in other words, had lubricated the contact surfaces between concrete and clay, so that there was little friction between them to resist the horizontal force of the water in the forebay. The full force of this water had then been impressed on the tops of the 10,000 or so bearing piles and bent them toward the river; the power house was taken with them.[44]

The deflection had not occurred immediately, Lindenthal explained, because it took some time for water to penetrate the clay puddle used to seal the forebay floor. It had occurred rather soon after the plant had gone into limited operations because either the vibration of the turbines had distrubed the clay puddle, permitting water to percolate under the foundations, or, possibly, because the ice which formed in the forebay during the first winter had, due to the shape of the forebay, exerted additional pressure on the power house toward the river.

To remedy the defectes in the power house Lindenthal had two suggestions. To prevent deflection he recommended that a number of inclined iron tubes or piers, filled with concrete, be sunk to bedrock using compressed air methods on the north side of the power house. He left the size, number, location, and plans open until information on the exact nature of the underlying material could be determined by borings. To seal the forebay from washout he suggested completely enclosing the foundation with sheet piles.[45]

Lindenthal only sketched the repairs he believed were necessary. His ideas were taken up, expanded, detailed, and modified by L.H. Davis, von Schon's replacement as chief engineer. In 1905 Davis proposed placing 40 inclined cast iron buttresses, 5 to 6 feet in diameter, filled with concrete, at the rear of the power house. To solve the leak problem he advocated interlocking steel sheet piling. This would be driven to bed rock across the forebay and into the forebay embankment about 300 feet in front of the power house. Between the sheet piling and the power house Davis suggested removing the 1903 forebay floor. Once this was done additional piles would be driven. The piles would then be capped with 12" x 12" sills followed by a layer of 2-inch planks. A second tier of 12" x 12" sills run perpendicular to the power house would follow. These would be topped by 6-inch groove and spline planking. The second tier of 12" x 12" sills would leave drainage channels in the floor some 4 feet wide by 1 foot high leading directly to the forebay walls. At the forebay a water tight floor would form an inclined apron to the penstock chambers. Under the watertight apron a chamber would collect the water from the drainage channels and discharge it into the tail pits through 24-inch diameter valves if the pressure against the forebay side of the building exceed that in the tailrace.[45] (See HAER drawing, sheet 7 of 8)

Lindenthal and Davis were but the first in a series of engineers who studied the power house. After the 1904 leaks several other groups of consultants were called in to report on possible means of remedying its defects. The first to report was the team of Clemens Herschel and Alexander Pringle. They visited the site with von Schon and Davis around September 1904. Clemens Herschel (1842-1930), like most of the other consultants engaged by the power company, was an engineer of the highest caliber. A graduate of Harvard, with additional European education, he had been one of the designers of the test flume at Holyoke. For his invention of the "Venturi meter" Herschel had been awarded the Elliott Cresson Medal of the Franklin Institute and the Thomas Fitch Rowland Prize of the American Society of Civil Engineers. He had been on the board of engineers which made recommendations for the turbine installation at Niagara Falls. A future president of the American Society of Civil Engineers, he was perhaps the best American hydraulic engineer available.[47] His associate Alexander Pringle was a respected Canadian hydraulic engineer.

Herschel and Pringle came to Sault Ste. Marie looking for a dam and did not find one:

> . . . to make a waterpower there must necessarily be a dam, but in the present instance the necessary element constituting such a dam does not plainly exist. On the other hand the Manufacturing Building is so prominent that it abstracts the thought of and causes one not to notice the absence of the dam required beneath the upper and lower water levels.[48]

The only dam-like element they found at the power house was the row of sheet piling driven at the upstream face after the 1903 washout. And sheet piling, they felt, could never be made completely water tight.

Herschel and Pringle sought to remedy the leak and deflection problems with a single construction. They proposed driving two rows of sheet piling in the forebay to bedrock immediately in front of the power house. The soil between these rows would be excavated and a concrete dam around 25 feet thick built from the bedrock up to the level of the forebay floor. This would eliminate leakage. Steel anchor rods running from the dam into the power house sub-structure would provide the needed lateral stability.[49] (See HAER drawing, sheet 7 of 8)

John A. Wilde, chief engineer of the Canadian "Soo" hydropower plant was also asked for his recommendations in 1905. Wilde believed that if water could be prevented from penetrating below the power house both the deflection and the leakage problems would probably be solved. He suggested that this could be accomplished by excavating a trench around 30 feet deep the entire length of the building just a few feet in front of the penstocks. This trench would be refilled with a puddle core of mixed clay and gravel. Cavities already created under the power house would be cured by stock ramming. If making the forebay watertight with this construction did not simultaneously solve the deflection problem, he asserted, it should be considered separately at some later time.[50] (See HAER drawing, sheet 7 of 8)

A third report was developed and delivered in 1905 by Samuel Whinery, with the assistance of Boller and Noble. Original intentions were for Whinery to work in conjunction with Herschel and Pringle, but Herschel refused to work with Whinery on the grounds that he had participated with Boller and Noble in investigating the repairs made in 1903 and had concurred in their conclusion that those repairs should make the structure secure. This, Herschel felt, would prejudice Whinery's attempt to find an alternative solution.[51]

Whinery was thus excluded from Herschel's investigation. But he, Boller, and Noble were requested to study the problem on their own and make a separate report. Samuel Whinery (1845-1925), who played the major role in the investigation, was born in Ohio, educated in Indiana. Although he had attended the University of Indiana for several terms, he was largely a self-taught engineer. His first practical experience came in railroad construction, and most of his early work involved the construction and location of railroads. He did, however, participate in the Muscle Shoals Improvement of the Tennessee River between 1878 and 1881, gaining some early hydraulic experience. His later work involved high construction, water supply engineering, and river improvements. Whinery in March 1901 set himself up as an independent consultant in New York. A former vice-president of the American Society of Civil Engineers, he was not as well known to the general public as Boller, Lindenthal, Noble, or Herschel. But he was well-known and well respected within the engineering profession.[52]

The Whinery-Boller-Noble plan was to some degree similar in conception to the attempts made to repair the power house in 1903. That is, the power house was to be reinforced by tying it into a strengthened, leak-proofed forebay foundation. But the methods proposed in 1905 represented a significant improvement over the steps that had been taken (partially at their recommendation) in 1903.

Whinery proposed removing the existing plank covering in the forebay and excavating the clay beneath to a depth of 3 feet. For a distance 150 feet back of the power house new piles, equal in number to those already in the forebay area, would be driven among those already in place. A layer of crushed stone 1.5 feet thick would be placed on the excavated floor, and upon this layer of stone a bed of reinforced concrete 2.5 feet thick would be poured. In this concrete a system of steel eye-bars would be implanted. These would be carried to the power house sub-structure, passed through the forebay wall, and securely anchored to the building. This step, Whinery believed, would have the effect of extending the foundation of the power house and lending additional lateral resistance to the structure. To give further security, particularly against washouts, the layer of concrete was to be carried back into the forebay an additional 100 feet, to a distance of 250 feet from the power house, but at a reduced thickness of 1.5 feet. At the junction of the concrete floor with the power house a flexible water-tight joint was to be contructed, while along the upper edge of the concrete a continuous line of interlocking steel sheet piling was to be driven to bedrock. Any water that did penetrate the sheet piling and the concrete lining of the forebay area would drain through the stone beneath the concrete to the forebay wall and then, through openings placed in that wall beneath the concrete, flow harmlessly into the tail pits or tail races.[53] (See HAER drawing, sheet 7 of 8)

Yet another plan for remedying the power house defects was sketched by the Foundation Company of New York in 1905. This scheme, sometimes referred to as the "bathtub scheme", contemplated transforming the forebay (save for the point at which the canal entered) into a self-contained watertight basin. Reinforced concrete with steel anchorages was to be poured over the entire forebay from the power house to the forebay embankment walls to make the forebay floor water tight. To sustain the power house against the thrust of the water an inclined sloping concrete wall, built on batter (or inclined) piles, would be built against the forebay embankments opposite the power house. Tie rods leading from the steel anchorages embedded in the concrete forebay floor would curve gradually from a horizontal position in the floor to a near-vertical position in the wall. Running across the front of the power house at the forebay wall there would be a continuous steel girder. This would be tied into the reinforced concrete forebay floor. Eyebars from this steel girder would penetrate the forebay wall and be tied into steel grillage embedded in the pit walls about 30 feet from their upstream ends. Sheet piling driven to bedrock where the power canal entered the "bathtub" would prevent seepage beneath the concrete floor.[54] (See HAER drawing, sheet 7 of 8)

Of the various schemes for power house repair delivered to the receivers between 1903 and 1905, three seem to have been given very serious consideration:

Lindenthal's 1903 scheme, as modified by Davis in 1904-05
Herschel and Pringle's 1904 scheme
Whinery, Boller, and Noble's 1905 scheme

Each of these groups was asked at various times in 1905 and 1906 to deliver critiques on the other's proposals.[55] The Davis-Lindenthal scheme was criticized for being too costly due to the dangerous and unusual character of the pneumatic work it would involve and for continued reliance on timber and clay for water-proofing in the forebay. Herschel and Pringle's dam scheme would have involved an even larger expense and shutting down the plant for an extended period of time. It was feared that the concrete forebay proposed by Whinery and his associates would crack due to the temperature extremes experienced in Sault Ste. Marie. It was also argued that the additional strength it provided the power house was sufficient only up to a 17 foot head.

By late 1905 the options seem to have been narrowed to two: the Davis-Lindenthal scheme or the Whinery-Boller-Noble scheme. Davis and Whinery met in November 1905 to agree on common data by which they would both work out their computations and estimates. At a conference lasting from November 16, 1905, Whinery and Davis both revised their plans in the light of the other's criticisms, set standard costs for labor and materials so that their estimates of construction costs could be fairly compared, and agreed on methods for computing the forces that any remedial works would have to withstand. They also agreed to tailor their reinforcement plans so that the power house could withstand up to a 24 foot head.[56]

By early 1906 there seems to have been general agreement that the Davis-Lindenthal scheme was probably the most effective remedy for the defects in the power house. The only questions preventing its adoption were those of practicality and cost. To clear up these matters the company asked Howard A. Carson (1842-1931) to review Davis' proposals in these areas.

Carson, Massachuetts born, had served in the Corps of Engineers during the War for Southern Independence, and on the termination of that conflict had attended M.I.T. He graduated in 1869 with a degree in civil engineering. Most of his early experience was in the area of hydraulic engineering, specifically the construction of water works and sewers. From 1878 to 1884, for instance, he had supervised the construction of the Boston Main Drainage System, inventing the Carson trenching machine which was used in the construction of these works. He afterwards became president of the Carson Trench Machine Company, which built trenching machines used extensively throughout the country. During the 1880s and early 1890s Carson had designed sewerage systems all over Massachusetts. From 1894 to 1909 he served as chief engineer of the Boston Transit Commission, designing some of the earliest American subways (the earliest electrically power ones) and the first underwater tunnel for subway service in the country. His retention by the receivers of the Consolidated Great Lakes Corporation to study Davis' plans was, therefore, a continuation of that company's policy of employing for consultation services only engineers of the highest professional reputation.[57] Carson consulted with Davis in February or March of 1906.

Davis had estimated that the repairs he proposed for the forebay area would cost around $175,000; the buttress installation around $227,000, for a total of $402,000. Carson estimated the costs at around $460,000 and apparently felt that the Lindenthal-Davis scheme was practical and that Davis' estimates, slightly revised, were reasonable.[58] Boller, who favored the Whinery scheme, remained unconvinced. He wrote in July 1906 of the pneumatic buttresses the Davis plan involved:

> It is about as nasty a job as I have ever run across to get those tube in, establishing the air lock and shield device, under the peculiar conditions, and I have run up against a good many tough propositions in the last forty years.[59]

Nonetheless, the receivers applied to the U.S. Circuit Court of the Western District of Michigan that summer for permission to issue receiver's certificates for $500,000, the proceeds of which would be used to repair the power plant in conformity with Davis' plans. By August 1906 the courts had granted permission for the certificates and by September Davis had prepared specifications for bidders.[60]

The response of construction companies to the Davis plans was disappointing. The J.G. White Company of New York, for example, told co-receiver C.D. Warren in October that "all the work involves a great deal of risk, particularly the compressed air work". Unforseen developments, they observed, might add up to 50% to estimated costs. Since they were busy with work involving no risk, they would consider the job on a cost plus profit basis only.[61] In a similar vein the Foundation Company expressed reluctance to bid, noting "the difficulties involved and the uncertainties as to costs".[62] By January 1907 all the bids were in. The best bid was from John Griffith Sons of Chicago for $700,000, well above the amount the receiver's certificates authorized.[63]

Oavis considered all of the bids "Unwarrantably high" and consulted with Carson once again.[64] Carson blamed the poor results on the abundance of construction work available at the time and the unusual nature of the project which caused contractors to add to their estimates to cover contingencies. He suggested that the company should contract to have one buttress installed in order to establish the practicality of the scheme and give some solid idea of costs.[65] On February 7, 1907, the bondholders and directions of Consolidated Lake Superior met in Philadelphia. At that meeting Carson's advice was followed. All the bids received on the comprehensive scheme were rejected, and Davis was instructed to prepare specifications and proposals for bids on a trial buttress of his design. Davis had urged the company to undertake the installation of the buttresses itself, feeling that he could keep the costs under $500,000.[66] But this plan was rejected because of the low price which the receiver's certificates were likely to bring on the market.[67]

By the end of March 1907 bids for a single trial buttress had been received. All three companies submitting bids had asked for the job on a cost plus fixed fee basis.[68] The company found this unacceptable. There is some evidence from the spring and summer of 1907 that the company had decided to undertake the construction of a trial buttress on its own.[69] But during the summer of 1907 Davis apparently received instructions to postpone power house reinforcement indefinitely.

A number of factors seem to have been involved in this decision. The generally poor financial condition of the company was probably one, especially in view of the higher-than-expected costs for the reinforcement schemes. The break-down of negotiation with Chandler-Dunbar in the summer of 1907 and the pending litigation over water rights with that company was clearly another factor. Brown in a letter to his co-receiver in November 1906 had argued that issuing receiver's certificates before the Chandler-Dunbar issue was settled would be a mistake.[70]

The situation of the Michigan Lake Superior Power Company between 1903 and 1913 is perhaps best summed up by the old addage -- "between a rock and a hard place". In order to escape their financial dilemma, the company needed to produce more power. But expensive repairs were needed to produce the additional power. Because the repairs were expensive, the company could not afford to make them, which meant that they could not produce the additional power needed to escape their financial bind. It was probably enough to make the bondholders want to cry.

There was one possible alternative. Davis had estimated that the plant's power could be increased from 10,000 to 14,000 h.p. by making repairs to the power house.[71] A comparable or perhaps even greater increase could be obtained by diverting more water from the St. Mary's. The embankment in front of span 10 of the International Bridge and the 4 gates in front of span 9, constructed in 1901-1902, were intended to compensate for a diversion of around 10,000 c.f.s. As early as 1904 von Schon, in his final report to the company, had noted that these works were not blocking a sufficient portion of the normal flow over the rapids and that this might, in the future, cause complications with the Corps of Engineers.[72] The inadequacy of the existing compensating works to meet even the small flow in use was called to the attention of the receivers several times in 1905 and 1906 by Davis.[73]

No steps, however, were taken to remedy the matter and to increase diversion until 1907. The unexpectedly high bids on the Lindenthal-Davis buttressing scheme led Davis and the company's directors to consider increasing the plant's power output by additional water diversion instead. In February 1907 Davis estimated that an additional set of 4 compensating gates, without any additional equipment at the power house, would probably increase power output from 10,000 to 14,000 h.p., about the same increase expected from power house reinforcement.[74] An even greater increase could have been gained by both increasing the diversion from St. Mary's and installing more turbines and generators, but as early as 1905 Union Carbide had refused to consider installing any more equipment until the power house was repaired.[75]

Davis proposed in 1907 that the company request permission to extend the breakwater left in place after the completion of the first set of compensating gates.[76] This could be done cheaply, and, he felt, would serve as a temporary expedient until the company could afford to install more permanent works. This project was seriously considered. Plans for the breakwater were apparently drawn up in late 1907, and in 1908 petitions were prepared seeking permission from the courts to spend the necessary moneys.[77] This project, however, was also stymied by the company's legal problems. The matter was not pushed to a conclusion since the company's lawyers felt that the courts would not authorize an extension of the compensating works onto lands not owned by the company and where damage suits with Chandler-Dunbar might result.[78]

The passage of the 1909 Rivers and Harbors Act, which authorized the Corps of Engineers to condemn the property in the rapids, renewed MLSPC's hopes for increasing the power output by increasing the volume of water diverted. Even though company officials were informed that the War Department would consider no leases until condemnation proceedings were out of the way,[79] the firm of Noble and Woodard was retained to report on the effects of a wing dam on Lake Superior water levels.[80] In

December 1909 the company formally requested permission to extend the breakwater.[81] The District Engineer in Detroit, Townsend, recommended that the petition be refused until the whole status of property in the rapids was cleared up.[82] In January 1910 the company's request was formally rejected by Washington.[83]

Noble and Woodard were also requested by the company to draw up plans for remedial works which would allow a diversion of 30,000 c.f.s. through the power canal. This report was delivered in January 1910. It recommended 3 sections of 4 compensating gates each, a movable dam section, a dike section, and left one span of the International Bridge completely open. This report had to be revised and supplemented in 1910 after the completion of the new government dike, constructed a considerable distance to the north of the old Chandler-Dunbar dike.[84]

By late 1911 legal matters in the rapids were finally beginning to clear up. Thus in September the company again made formal application to the War Department to divert additional water through the power canal.[85] Protracted negotiations ensued between MLSPC and the Corps of Engineers over the form the regulating works were to take, the rules to govern their operation, and the payment to be made the government for the water diverted. Noble and Woodard were retained by the company through most of the negotiations.[86] They were finally brought to a successful conclusion in the spring of 1913, at about the time the Michigan Lake Superior Power Company was absorbed by Union Carbide.[87]

CHAPTER VI: Footnotes

1. Herschel and Pringle to Lake Superior Corporation on Engineers Commission to Examine the Michigan-Soo Water Power. (Sic) November 1, 1904 (vf 222.2.10-3)

2. Sault Democrat. January 17, 1889

3. "Report to the Lake Superior Power Company on Remedial Works at Head of St. Mary's Rapids, May 25, 1897," (OCf, A. Noble, Reports) p. 1

4. Lt. Col. G.J. Lydecker to General John M. Wilson, Sept. 10, 1898 (Library of Congress, UG 23, U.S. Army Corps of Engineer Special Orders- 1898 & 1899) pp. 2-3

5. Ibid. Lydecker to American Lake Superior Power Company, November 1, 1898, p. 25.

6. Ibid. Clergue to Lydecker, November 4, 1898, p. 25

7. Sault News. November 9, 1898

8. Ibid.

9. "Statement of Chandler-Dunbar Water Power Company" Chandler to Lydecker, December 9, 1898. (Engineers Special Orders 1898-1899) p. 27

10. "Report of the Board of Engineers to General John M. Wilson," (Engineers Special Orders 1898-1899) pp. 9-12

11. Ibid.

12. Sault News. February 18, 1899

13. Michigan Lake Superior Power to General John W. Griggs, March 14, 1899 (Engineers Special Orders 1898-1899)

14. American Council of Learned Societies, Dictionary of American Biography. (New York: Charles Scribner' Sons, 1928) Russell Alexander Alger

15. R.A. Alger to E.V. Douglas, March 22, 1899 (Engineers Special Orders, 1898-1899)

16. Sault Democrat. July 6, 1899

17. Sault News. February 17, 1900

18. John Shaw to William Livingstone, (vf 3-9)

19. "Application of Clarence M. Brown, Receiver of the Michigan Lake Superior Power Company, to the International Joint Commission, June 27, 1913." (vf 165.3.2-1) p. 2

20. Ibid. p. 6

21. "Discussion of the Situation at Sault Sainte Marie, Michigan, 1908." (vf 1-130) p. 42

22. Ibid. p. 42

23. Ibid. p. 28

24. "History of Edison Sault Electric Company, December 15, 1891 to December 31, 1971." (Edison Sault files in main office.) p. 1-2

25. Ibid. p. 3

26. "Situation at Sault Ste. Marie." pp. 34-35

27. Sault News. August 10, 1895

28. "Situation at Sault Ste. Marie." p. 53

29. "Memorandum Brief on Proposed New Power Company at Sault Ste. Marie, MI. (vf 4. St. Mary's Power Company File)

30. Clergue to Cady, July 19, 1901 (VP 216-218)

31. Clergue to Cady, August 19, 1901 (VP p. 240)

32. William Chandler to the Michigan Lake Superior Power Company, September 21, 1901 (VP 257-259)

33. Clergue to the Chandler-Dunbar Water Power Company, October 24, 1901 (VP 268-269)

34. Reports, Vol. 1. pp. 20-35

35. "Situation at Sault Ste. Marie." p. 41

36. Clergue to John Shaw, March 25, 1902 (VP 366-368)

37. St. Marys Power Company to the Hon. Secretary of War, April 22, 1903 (vf 4. St. Marys Power Company File)

38. "Situation at Sault Ste. Marie." p. 41

39. Sault News. November 30, 1895

40. Clergue to Harper, March 14, 1901 (VP 146)

41. <u>Specifications</u> p. 280

42. <u>Sault News</u>. July 23, 1898

43. Clergue to Messrs. Cobb & Wheelright, September 6, 1902 (VP 477)

44. "American Alkalai Contract." (OCf)

45. <u>Sault News</u>. June 10, 1899

46. "A Report on Geological Conditions and Mineral Resources in the Upper Peninsula of Michigan with special reference to the precense of salt." H. von Schon, March 1898, <u>Reports</u>. Vol B

47. <u>History of Consolidated</u>. p. 35

48. <u>Sault News</u>. July 23, 1898

49. B.J. Clergue to von Schon, July 30, 1902 (VP 452)

50. "The Consolidated Lake Superior Company, President Shields Report," <u>The Iron Age</u>, v. 72, p. 5.

51. Clergue to von Schon, July 25, 1902 (VP 450)

52. Clergue to Hummel, November 13, 1901, (VP 285)

53. Clergue to E.V. Douglas, December 14, 1901 (VP 298)

54. <u>Sault Daily News-Record</u>. November 10, 1902

55. <u>Contract</u>. May 23, 1903, pp. 347-348

56. Clergue to B.W. Cottrell, October 10, 1902 (VP 500)

57. Clergue to Geo. B. Goodwin, October 29, 1902, (VP 519)

58. Clergue to von Schon, February 16, 1903, (VP 591)

59. <u>Sault Daily News Record</u>. October 13, 1902

60. <u>Sault Democrat</u>. January 9, 1896

61. Eldon, <u>Explorations</u>. p. 258

62. <u>History of Consolidated</u>. p. 21

63. <u>Ibid</u>. pp. 24-25

64. Sault News. June 10, 1899

65. History of Consolidated. p. 42

66. Clergue to Messrs. R.G. Dun & Co., November 5, 1900 (VP 41)

67. Clergue to von Schon, October 5, 1900 (VP 9)

68. "Estimates of Expenditures," (Misc. f)

69. "Electrochemistry at Sault Ste. Marie," Electrochemical Industry, v. 1, p. 85, November 1902.

70. History of Consolidated. p. 42

71. Ibid. p. 23

72. Ibid. p. 22

73. Ibid. p. 21

74. Ibid. p. 78

75. Ibid. 105

76. Ibid. p. 78

77. Ibid. p. 79

78. Sault Daily News-Record. December 12, 1902

79. History of Consolidated. p. 82

80. Ibid. p. 86

81. Ibid. p. 92

82. Eldon, Explorations. p. 263

83. History of Consolidated. p. 101

84. Ibid. pp. 102-103

85. Ibid. p. 104

86. Eldon, Explorations. p. 264

87. Ibid. p. 264

88. Can Every, <u>Clergue and the Rise of Sault Ste. Marie</u>, p. 202

89. Sullivan, <u>Clergue</u>. p. 151

90. <u>Ibid</u>. p. 201

91. Davis to Warren, February 18, 1905 (vf 24-7 1/2)

92. "Decree of Foreclosure, July 11, 1913," (vf 192-194) p. 2

93. C.D. Warren to Sault, Michigan Chamber of Commerce, December 27, 1905 (Mf 24112)

94. "Decree of Foreclosure," (vf 192-194) p. 133

95. <u>Electrical World</u>, August 25, 1906

96. Brown to Warren, November 15, 1906 (Mf 24112)

97. "Memorandum Opinion, on the United States of America vs. The Chandler Dunbar Water Power Company." (vf 1-5)

98. Davis to Sawyer, September 2, 1905 (Mf 24112)

99. "The International Joint Commission," <u>The Round Table</u>. 1915, p. 2

100. <u>The Soo Times</u>. August 13, 1905

101. "International Waterways Commission Rules and Regulations," (vf 13-26)

102. <u>Soo Times</u>. May 12, 1906 (vf 1-204)

103. <u>Sault Evening News</u>. November 18, 1905

104. Sawyer to Warren, November 24, 1905 (Mf 24112)

105. Democratic political leaflet, 1906. (Mf 24112)

106. Chippewa County Crange political leaflet, February 8, 1908 (Mf 24112)

107. J.S. Wynn to N.W. Rowell, March 5, 1907 (Mf 24112)

108. "What About This Much Talked of Specific Tax Proposition?" (Mf 24112)

109. J.S. Wynn to N.W. Rowell, March 5, 1907 (Mf 24112)

110. "Report of Charles D. Warren and Clarence M. Brown," (vf 1-129)

111. Soo Times. April 4, 1908 (vf 1-272)

112. Sault Evening News. February 11, 1907 (vf 1-230)

113. "Rivers and Harbors Act, March 2, 1907, (Public No. 168)" (vf 1-23)

114. Soo Times. February 29, 1908 (vf 1-284)

115. Ibid. April 4, 1908 (vf 1-274)

116. Ibid. June 6, 1908 (vf 1-245)

117. Supreme Court Reporter #28, National Reporter System, United States Series, Cases Argued and Determined in the United States Supreme Court (St. Paul, West Publishing Company, 1908) pp. 579-581

118. Soo Times. June 6, 1908 (vf 1-245)

119. "Rivers and Harbors Act of 1909, H.R. 28243, (Public No. 317)." (vf 1-167) pp. 6-8

120. Sault Evening News. September 27, 1909 (vf 10-0)

121. L.M. Butzel to L.H. Davis, February 22, 1911 (vf 10-15)

122. Sault Evening News. January 2, 1912 (vf 10-75)

123. "Water Power Opinion of the Supreme Court of the United States, Plaintiff in Error vs. the Chandler-Dunbar Water Power Company Et. Al., Senate Document No. 51." (vf 10-110)

124. L.H. Davis to W.C. Franz, August 12, 1909. (vf 17-219)

Footnotes: Chapter VI, Part 3

1. von Schon, General Report, pp. 14-15

2. Ibid., p. 15

3. von Schon to Clergue, December 6, 1902 (PL 7, 117-18)

4. von Schon, General Report, pp. 15-16

5. von Schon to Boller, April 3, 1903 (GL 22, 209-13); Boller, Whinery, and Noble to von Schon, April -5, 1903 (vf 222,2,5-1); von Schon, General Report, pp. 16-17

6. von Schon to Boller, April 3, 1903 (GL 222, 209-13); Boller, Whinery, and Noble to von Schon, April 25, 1903 (vf 222.2.5-1); von Schon, General Report, pp. 16-17.

7. Boller, Whinery, and Noble to von Schon, April 25, 1903 (vf 222.2.5-1)

8. Shields to Boller, October 8, 1904 (Mf 24090), citing a report of February 13, 1903.

9. von Schon to Shields, April 14, 1903 (PL 7, 245-46), estimated completion of repairs would cost $50,000 more. How much had been spent up to this point is not mentioned.

10. von Schon to W. Coyne, June 13, 1903 (PL 7, 320)

11. von Schon to Shields, May 13, 1902 (PL 7, 282); von Schon to Shields, July 17, 1903 (PL 7, 376-77).

12. Shields to Boller, October 8, 1904 (Mf 24090)

13. Boller to Shields, September 21, 1904 (Mf 24090). Boller had invested heavily in the project and was thus personally concerned with its outcome.

14. Shields to Boller, October 8, 1904 (Mf 24090).

15. Von Schon left the company with ill-feelings. There was a dispute between he and the company over unpaid salary, the mortgage of the house von Schon was living in, and certain company documents held by von Schon. See Mf 24084 for correspondence on this matter between October and November 1904.

16. Bernhard Dernburg, "Why This War?" Some Plain Facts Regarding European Militarism and the Causes of the War," Water Chronicle, v. 4 (1914) pp. 148-51

17. "Memoir of von Schon," pp. 1541-42, and scattered passages in his Hydro-electric Practice

18. Oavis to J.S. Fackenthal, April 16, 1904 (Mf 24068); Oavis to B.F. Fackenthal, October 10, 1903 (vf 222,4-2)

19. Oavis to J.S. Fackenthal, September 22, 1904 (vf 129.1-3)

20. ? to B.F. Fackenthal, September 7, 1904 (vf 129.1-1)

21. ? to B.F. Fackenthal, September 8, 1904 (vf 129.1-2)

22. Oavis to J.S. Fackenthal, September 22, 1904 (vf 129.1-3); Oavis to Shields, October 4, 1904 (vf 129.1-4)

23. Davis to Whinery, September 3, 1905 (vf 129.2-1); Oavis to Sawyer, February 8, 1905 (vf 129.2-3)

24. Oawson to Davis, March 4, 1910 (vf 129.4-18½) describes the equipment used for ramming clay in 1910. The filler pipes used in 1905 were probably similar in principle, but with force provided by hand rather than by very large weights.

25. Oawson to Davis, September 1, 1905 (Ef 45); Oavis to Whinery, September 3, 1905 (vf 129.2-1)

26. Oawson to Davis, December 8, 1905 (Ef 45)

27. Oavis to J.S. Wynn, October 18, 1907 (vf 129.3-2); Davis to Warren, October 23, 1907 (vf 129.2-12); Oavis to Brown, March 13, 1908 (vf 129.3-37); Oawson to Wynn, November 17, 1907 (vf 129.3-32).

28. Oawson to Wynn, November 17, 1907 (vf 129.3-32); see also Ef 45.

29. Davis to Brown, May 29, 1909 (G1-2, 4, 302-04).

30. Davis to Franz, November 11, 1909 (vf 129.4-16); Oavis to Franz, November 23, 1909 (vf 129.4-16); see also Ef 45

31. Dawson to Oavis, March 4, 1910 (vf 129.4-18½) for a description of the clay ramming equipment used.

32. Ef 45.

33. Photo of crack, January 11, 1910 (vf 129.4-16½)

34. Oawson to Oavis, March 3, 1910 (vf 129.4-18)

35. Oawson to Oavis, March 3, 1910 (vf 129.4-18)

36. Davis to Brown, May 7, 1910 (Mf 27 8)

37. Davis to Franz, December 27, 1909 (Mf 27 8)

38. Franz to T.J. Kennedy, February 18, 1910 (Mf 27 8)

39. Davis to Franz, April 22, 1910 (Mf 27 8). The Soo Businessmen's Association had petitioned the War Department for an allowance of enough water for one turbine, and the company had gone along with their drive even though they had already made a decision to shut down the plant completely (Franz to J.F. Taylor, March 2, 1910 (Mf 27 8)). Apparently, the company was trying to keep up the appearance of being public spirited, hoping that the petition would be turned down by the War Department and that they would look good for trying.

40. Ef 45.

41. Davis to Fackenthal, January 15, 1904 (vf 17-10); Davis to Sawyer, December 28, 1906 (vf 222.1-15); also Record of Switchboard Output. All of these indicate that the average output per turbine was on the order of 350-360 h.p.

42. "Lindenthal, Gustav," A Biographical Dictionary of American Civil Engineers, New York, 1972, pp. 81-82

43. "Report of Gustav Lindenthal . . .," May 25, 1903, in von Schon, General Report, p. 43; also in vf 222.2.1-1

44. "Discussion of Stability of 500 h.p. unit penstock Installation against Sliding," Report by J.W. Rickey, October 7, 1897 (Reports, A, esp. 177, 179) seems to indicate some reliance on friction in stability calculations.

45. "Report of Gustav Lindenthal," in von Schon, General Report, pp. 41-47; see also vf 222.2.1-1 for a copy of Lindenthal's report.

46. Davis to Sawyer, January 4, 1905 (vf 222.2.7-4)

47. "Memoir of Clemens Herschel," ASCE, Transactions, v. 95 (1931) pp. 1419-23; also Hunter Rouse, Hydraulics in the United States 1776-1976, Iowa City, 1976, pp. 60-62.

48. Herschel and Pringle to the Lake Superior Corporation on Engineers Commission to Examine the Michigan-Soo Water Power (Sic), October 1, 1904 (vf 222.2.10-3)

49. Ibid., and Herschel and Pringle to Engineers Commission etc., November 1, 1904 (vf 222.2.10-4). See also vf 222.2.3-6 and 222.2.3-8 for other copies of the Herschel and Pringle preliminary and final reports.

50. Wilde to W.N. Sawyer, February 16, 1905 (vf 222.2.10-10; also vf 222.2.4-1)

51. C.D. Warren to Shield, September 12, 1904 (Mf 24088); C. Orvis to Herschel, Whinery, and Pringle, September 12, 1904 (Mf 24088); Herschel and Pringle to Whinery, September 21, 1904 (Mf 24088); Shields to Orvis, telegram, September 14, 1904 (Mf 24088)

52. "Memoir of Samuel Whinery," ASCE, Transactions, v. 89 (1926) pp. 1701-05.

53. "Preliminary Report on Strengthening the Foundation of the Power House of the Michigan Lake Superior Power Company, Sault Ste. Marie, Michigan," Whinery to Boller, September 1905 (vf 222.2.5-16); Whinery to Boller, December 14, 1905 (vf 222.2.5-24); Whinery to Boller, November 28, 1905 (vf 222.2.5-20)

54. Reprinted in S.H. Woodard, "Report on Reinforcement of Power House at Sault Ste. Marie, Mich. . .," September 10, 1915, Appendix VII (vf 222.2.8-29)

55. Herschel and Pringle to Orvis, February 18, 1905 (vf 222.2.10-7); Davis to Warren, March 21, 1905 (vf 222.2.10-9); Davis to Sawyer, September 23, 1905 (vf 222.2.10-17); Whinery to Boller, November 8, 1905 (vf 222.2.10-20)

56. Davis to Sawyer, December 9, 1905 (vf 222.2.10-22).

57. "Memoir of Howard Adams Carson," ASCE, Transactions, v. 96 (1932) pp. 1386-87

58. Carson to Warren, February 23, 1906 (Mf 24112); Davis to Warren and Brown, February 16, 1907 (vf 222.7.1-5)

59. Boller to Davis, July 5, 1906 (vf 222.2.10-30)

60. Oavis to Sawyer, September 9, 1906 (vf 222.7-4)

61. F.H. Reed to Warren, October 19, 1906 (vf 222.7-15); J.G. White & Co. to Warren, October 10, 1906 (Mf 24112)

62. Boller to Warren, December 14, 1906 (vf 222.7.4-3)

63. Oavis to Wynn, January 23, 1907 (vf 222.2.10-37)

64. Oavis to Sawyer, December 20, 1906 (vf 222.7-119)

65. Carson to Warren and Brown, February 6, 1907 (vf 222.2.6-1)

66. Davis to Warren and Brown, February 7, 1907 (vf 222.2.10-38)

67. Davis to Wynn, February 26, 1907 (vf 222.2.10-39; also vf 222.2.7-13)

68. Davis to Wynn, March 22, 1907 (vf 222.2.10-40)

69. Davis to C.R. Perry, June 1, 1907 (vf 222.6-46)

70. Brown to Warren, November 15, 1906 (Mf 24112)

71. Davis to N.W. Rowell, February 13, 1907 (vf 165.0.3-2)

72. von Schon, General Report, pp. 31-33; von Schon to Shields, June 9, 1903 (PL 7, 312-13)

73. Davis to Sawyer, February 11, 19D5 (vf 165.0.2-3); Davis to Sawyer, December 28, 1906 (vf 165.0.2-25)

74. Davis to Rowell, February 13, 1907 (165.0.3-2)

75. Ibid.

76. Ibid. and Davis to Wynn, October 3, 1907 (vf 165.0.3-22)

77. Davis to Shaw, November 23, 1907 (vf 165.0.3-28); Rowell to Davis, telegram, December 2, 1907 (vf 165.0.3-31)

78. Franz to Davis, October 12, 1908 (vf 165.D.3-66); Rowell to Brown, October 26, 1908 (vf 165.0.3-67)

79. Brown to Rowell, April 21, 1909 (vf 165.0.1-19)

80. Davis to Franz, May 15, 19D9 (vf 165.2.1-1)

81. Davis to Col. C. McD. Townsend, November 12, 1909 (vf 165.D.3-120); Warren and Brown to Townsend, December 2, 1909 (vf 165.0.3-92); Davis to E.F. Price, December 14, 1909 (vf 17-232)

82. Davis to Franz, November 12, 1909 (vf 165.D.3-91); Davis to Franz, December 13, 19D9 (vf 165.0.3-126); Townsend to Davis, December 13, 19D9 (vf 165.0.3-127); Davis to E.F. Price, January 14, 1910 (vf 17-235)

83. J.M. Dickinson to Brown, January 26, 1910 (vf 165.0.3-136)

84. Davis to Noble and Woodard, September 12, 1910 (vf 165.2.2-97); "Study of Elevations of Lake Superior Under Efflux Conditions of 1899 and 1900," by Noble and Woodard, December 9, 1910 (vf 165.2.2-182)

85. "Application of Clarence M. Brown, Receiver of the Michigan Lake Superior Power Company, for approval of proposed lease with the United States . . .," June 27, 1913, p. 9 (vf 165,3,2-1) notes that the application was made on or about September 25, 1911, and that negotiations insued.

86. for example, Davis to Noble and Woodard, April 22, 1912 (vf 165.2.2-274)

87. "Application of Clarence M. Brown, Receiver . . .," June 27, 1913 (vf 165.3.2-1)

CHAPTER VII

NEW BEGINNINGS: THE ERA OF EXPANSION (1913-c. 1920)

REORGANIZATION

Throughout the period 1904-1908, the directors hoped the MLSPC could be reorganized and refinanced on much the same basis as the Consolidated Company had been reorganized into the Lake Superior Corporation and refinanced with a new mortgage. These hopes were based on the assumption that the legal dispute over water rights could be quickly settled and the needed power house repairs and erection of compensating works could be paid for with money received from the sale of receiver's certificates. The legal dispute continued, however, and it was found that the cost of putting the power complex into full production would be much higher than originally estimated.

In 1905 the 1st mortgage bondholders had been led to believe that the issuance of $500,000 in receiver's certificates was going to be enough to put the plant into full production. By 1908 they began to inquire why the certificates had not been sold and repairs to and completion of the power house begun. The Co-Receivers, Warren and Brown, issued a report in April of 1908 addressing these questions which stated that the certificates could not be sold until litigation with the Chandler-Dunbar Company reach a satisfactory conclusion and that negotiations with the company had reached a stalemate.[1] It was clear to the bondholders that the situation had not progressed since 1905 and there did not appear to be any solution close at hand.

The 1st mortgage bondholders committee which had been formed to represent the 1st mortgage bondholders in addition to the receiver Clarence Brown decided to inspect the company's financial situation more closely and found that estimates for completing the plant had risen to $1,775,000, well beyond the $500,000 that had been estimated in 1905.[2] This was alarming because the cost of the canal and power house had risen to $7,000,000 and the additional expenditure would bring the cost to nearly $9,000,000. It was doubtful that the MLSPC even under full production could pay off a debt this size, and a reorganization of the company appeared unavoidable.

In June 1908, shortly after the Co-Receiver's report, the 1st mortgage bondholders Committee called for a complete reorganization of the company. In November the Committee met with Warren and Brown to assess the company's alternatives for reorganization.[3] There are no records of what transpired during these negotiations, but later evidence shows that the Committee decided the only way to recoup a major portion of their investment would be to foreclose on the 1st mortgage and gain total ownership of the company's assets. This move would mean the total loss of the Lake Superior Corporation's investment in the company and they resisted. The 1st mortgage bondholders, however, had first lien on the company's assets and the Lake Superior Corporation's hands were tied.[4]

In May 1909 a detailed reorganization plan had been compiled by L.H. Davis which would have kept the MLSPC in the Lake Superior Corporation, but it called for the retirement of the first mortgage bonds at 60¢ on the dollar and would have passed the first lien on to a new mortgage.[5] Since this plan was never acted on, it is assumed the plan was found unacceptable by the 1st mortgage bondholders. The only other choice the Lake Superior Corporation had was to pay off the first mortgage, which by the end of 1909 had accumulated nearly $1,500,000 in interest. The total owed to 1st mortgage bondholders was $5,000,000, and unfortunately the Corporation did not have the money.

The Board of Directors of the Lake Superior Corporation decided that they could not hope to salvage any substantial amount out of the MLSPC, and that it was in their best interests to make what it considered a fair and amiable settlement with the 1st mortgage bondholders rather than to continue a fight which they would probably lose. The settlement finally agree on in 1910 turned over all assets of the company to the 1st mortgage bondholders, and the Lake Superior Corporation relinquished all interest and control for $200,000.[6]

Since the MLSPC had been managed by the Lake Superior Corporation from their main office in Sault, Ontario, it was necessary to prepare new offices and management staff for the owners. In May, 1910, the company began converting part of the boiler-room and pump house on the west end of the power house into office space.[7] L.H. Davis was named General Manager for the MLSPC (he had handled its supervision since 1903) although he expressed the feeling that his future would be much more secure if he could remain with the Canadian company. The General Manager of the Lake Superior Corporation, W.C. Franz, apparently felt the same way about the MLSPC and as the changeover progressed he wrote the vice president of the Corporation, "I will be glad if you can relieve me of having anything to do with the Michigan Company."[8] It seems as though the Lake Superior Corporation, although losing the investment made years ago in the MLSPC, had come to the conclusion that the possibilities of the company ever becoming profitable were very dim and they were not sorry to have it taken off their hands. The resignation of Charles Warren as Receiver of the MLSPC on March 28, 1911, signified the end of MLSPC as part of the huge Canadian industrial complex Clergue had constructed.[9]

Although sole ownership was now held by the 1st mortgage bondholders, the MLSPC's problems remained. In order to put the company into full operation a costly lease had to be arranged with the War Department and $2,000,000 would have to be obtained to repair and complete the plant. The company realized that if operations were to be profitable a new lease would have to be arranged with the Union Carbide Company. The current contract for 20,000 horse power at $10 per horse power per annum was obviously inadequate to create sufficient revenue to pay expenses. Additional power users would also have to be found to use the additional 20,000 horse power created when the plant went into full production.

When the MLSPC approached the Union Carbide Company about renegotiating its contract, the Carbide Company refused. Union Carbide did offer, however, to solve the MLSPC's problems by buying out the 1st mortgage bondholders and taking over the canal and power house themselves. Offered with a quick solution to their problems the bondholders accepted the offer. The agreement reached between the two parties was basically as follows:

1. The 1st mortgage bondholders would conclude foreclosure proceedings as quickly as possible, and sell the property subject to the lien of the Union Carbide Company's contract.

2. The committee would bid the par amount of the mortgage bonds ($3,500,000), and the property, upon sale, would be turned over to a new power company organized by and in the interest of the Union Carbide Company.

3. The new company was obligated to purchase the property and assets and to deliver to the Committee first Mortgage bonds of the company to the extent of fifty cents on the dollar of the face value of the 1st mortgage bonds of the old company (50% x $3,500,000 = $1,750,000 bonds of the new company).

4. The bonds of the new company would be guaranteed as to principal and interest by the Union Carbide Company.

5. The new company would pay the $200,000 owed to the Lake Superior Corp.[10]

This agreement was reached in March 1913 and announced in April. The citizens of Sault, Michigan, were generally enthusiastic about the news but were concerned that the Union Carbide Company would use all the power themselves instead of attracting small users of power with large work forces.[11] E.F. Price, vice president and general manager of the Union Carbide Company, reassured the city that the only reason the Carbide Company became involved was to assure that the plant could be completed so the carbide plant could operate at full capacity. He promised that it would be company policy to try to attract small users of power for the remaining 20,000 horse power available.

On August 6, 1913, the Michigan Northern Power Company filed articles of incorporation with the Chippewa County clerk. On October 13, 1913, the foreclosure sale took place on the steps of the county courthouse with the 1st mortgage bondholders as the only bidders. Under the terms of the agreement the property was turned over to the Michigan Northern Power Company.

The new power company backed by Union Carbide had no trouble securing the issue and sale of $4,500,000 1st mortgage bonds. The subtraction of the bonds owed the 1st mortgage bondholders of the MLSPC ($1,750,000) and the $200,000 owed the Lake Superior Corporation left $2,550,000 for the repair, improvement, and equipment of the power house and for the erection of the compensating works. The remaining obstacles blocking completion of the power development were the water lease and sanction by the International Joint Commission.

NEGOTIATING THE WATER LEASE

By Act of Congress dated March 3, 1909, the Secretary of War was given authority to dispose of the surplus waters at Sault Ste. Marie, for power purposes. As mentioned earlier, the MLSPC had immediately applied for a water lease at that time but the War Department had deferred on the grounds that no lease could be granted until an award had been made for the condemnation of land in the rapids.[13] In September of 1911 when the United States Circuit Court announced its awards in the case, Clarence Brown, now the sole receiver of the MLSPC, again applied to the Secretary of War for a water lease. Although the circuit court's decision was being appealed, the War Department agreed to begin negotiations on the terms of the water lease to the MLSPC.[14] These negotiations were conducted between Col. Mason M. Patrick, the Sault Ste. Marie engineer officer of the Corps of Engineers, and representatives of the MLSPC. The negotiations lasted more than a year and were concluded in June 1913, about the same time the Supreme Court made its determination on the award to the Chandler-Dunbar Water Power Company.[15]

The major provisions of the lease agreed to are as follows:

1. The MLSPC was granted a continuous flow of water to a maximum of 25,000 cubic feet per second, designated as "primary water," with a possible increase of 5,000 cubic feet per second as it is available, for the period of thirty years.

2. The lease waived and released all previous actions of the War Department and the provisions of the River and Harbor Act of 1902 in relation to the MLSPC.

3. The company was to build compensating and remedial works in accordance with plans furnished by the company and approved by the War Department, to insure a reasonable control of the level of the lake. The compensating works were to become the property of the United States with the cost of the works to be paid for by the government out of the rentals for water as they become due. The company was also to repair and strengthen the power house and forebay of its existing power plant to insure the most efficient use of the water.

4. Between the date of executing the lease and the completion of the foregoing works, the company was allowed to take not more than 15,000 cubic feet of water per second, and to pay therefore a nominal rental of $1,000 per annum. Upon the completion of the said works, the company was to pay a yearly rental of $2.50 per cubic foot per second for the entire 25,000 cubic feet of "primary water" and a rental at the rate of $1 per cubic foot per second per annum for all water in excess of the said 25,000 cubic feet, which the company could use intermittently for power development purposes.[16]

Since the lease dealt with the obstruction and diversion of internationl waters it was subject to approval of the International Joint Commission.[17] The IJC held hearings on the application of the Michigan Northern Power Company, which was in the process of completing the takeover from the Michigan Lake Superior Power Company, beginning in October of 1913.[18] Approval of the compensating works and the diversion of water was finally given by the Commission on May 26, 1914,[19] and on May 28, 1914, the lease with the United States was signed by the Michigan Northern Power Company.[20]

Since November 1898 when William Chandler had asserted his claim to riparian rights in the St. Marys Rapids, and since September 1903 when the Michigan Lake Superior Power Company was forced into receivership, the company had been prevented from putting the power house and canal into full production. With the formation of the Michigan Northern Power Company and the signing of the water lease with the War Department, the way had been cleared for the final completion of the power complex, over ten years after its grand opening celebrations.

Plant Expansion and Repair

The dissolution of the Michigan Lake Superior Power Company and the formation of the Michigan Northern Power Company as a wholly-owned subsidiary of the Union Carbide brought in an era of expansion at the power house. Between 1903 and 1913 the plant had stumbled along operating at a reduced head, almost annually plagued with forebay leaks, developing less than a quarter of the power it was designed to produce, cursed with constant financial and legal difficulties. With the coming of Michigan Northern many of these problems found solutions, for the new management took an aggressive attitude toward plant improvement.

EQUIPMENT EXPANSION

Even before formal foreclosure proceedings had been filed Union Carbide had begun to make plans for expanding their plant at the "Soo". In April 1913, for example, Union Carbide contracted with Westinghouse for the delivery of 19 new 60 cycle alternators.[1] By May preparations were being made to order 8 new turbine units (32 runners in 16 draft cases). These were ordered on August 25, 1913.[2]

The 8 turbine units were ordered from the S. Morgan Smith Company and were pre-tested at Holyoke like the original Jolly-McCormick models. They were installed in the spring and summer of 1915 in penstocks 44 through 51. In January of 1916 Michigan Northern ordered 14 more S. Morgan Smith units for penstocks 52 through 65. (See Figure 8) These units achieved almost 90% efficiency at Holyoke, probably the highest ever recorded for a low-head horizontal turbine at the test flume.[3] Also in early 1916, 15 Wellman, Seaver, Morgan turbine sets were ordered for penstocks 66 through 80. The 1916 S. Morgan Smith units were installed between June and October 1916; the Wellman, Seaver, Morgan units between December 1916 and April 1917. With these additions the turbine installation was finally completed, though with some changes from von Schon's original plans. He had intended to have 80 turbine units. Michigan Northern had only 78. They converted penstocks 1 and 81 to emergency spillways, in addition to the regular spillway at number 43, the only penstock von Schon had intended to use for that purpose. This change did not reduce the power capacity of the plant below the 40,000 h.p. von Schon had designed it for since the 1915 and 1916 turbines, as the chart on the following page indicates, were significantly more powerful than the 1901-1902 models.[4] (See HAER drawing, sheet 4 of 8)

Some thought was given to improving the old Jolly-McCormick units. Tests were carried out at Holyoke in 1919 and 1920 on the replacement of the old runners with new S. Morgan Smith runners while retaining the old Webster, Camp and Lane draft cases. The old runners, however, proved to be more efficient in the draft cases, than the Smith units, so the idea was dropped.[5]

As the turbine equipment at the power house was being brought up to full capacity, so was the generator equipment. While 19 new 60 cycle Westinghouse alternators were ordered, delivered, and partially installed in 1913 and 1914, (See HAER photo 88) the bulk of the expansion occurred, as in the cast of the turbines, in 1916 and 1917. In January 1916 Union Carbide placed an order with General Electric for 50 new 25 cycle alternators and 2 d.c. exciting units. This order was followed by an order with Westinghouse in February for rebuilding 19 of the original single phase, 90 volt, 60 cycle alternators to three phase, 4400 volt, 25 cycles. At the same time Michigan Northern arranged for Westinghouse to install all of the switchboard equipment for enlarged electrical installation.[6]

Both General Electric and Westinghouse did most of the installation work on their contracts in late 1916 and early 1917. By February 1917 the last of the work was completed and the plant, at least, was equipped to generate power at design capacity.

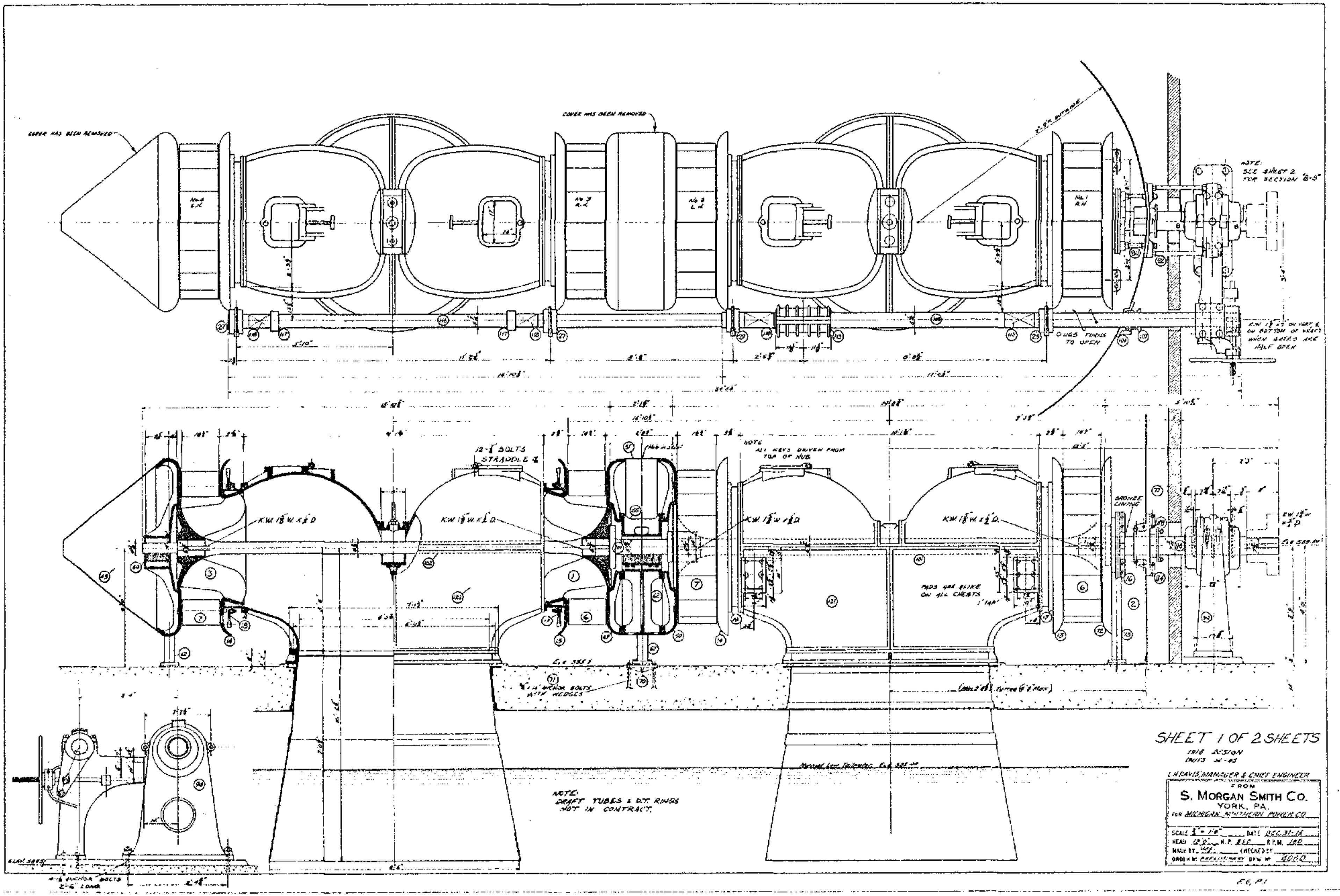

Figure 8: The 1916 S. Morgan Smith turbines and draft cases. MLSPC HAER MI-1 (page 206)

Table 16:

Turbine and Generator Plant at the M.L.S.P.C. Power House, pre- and post-1913

TURBINES

	Webster, Camp & Lane	S.Morgan Smith 1915 model	S.Morgan Smith 1916 model	Wellman, Seaver, Morgan
Output in h.p. at 18' head	686	802	810	837
Discharge, full gate, 18' head (c.f.s.)	420	500	496	526
Maximum Efficiency (Holyoke tests)*	82.4%	86.6%	89.12%	86%
Approx. gate at max. efficiency	.9	.65	.7	.75
No. of control gates per runner	10	16	16	16
Size of runner	33"	33"	33"	34¼"
No. of units at power house	41**	8	14	15
Date installed	1901-2	1915	1916	1916

*in-place efficiencies some 5-8% lower
**42 units prior to c. 1915

GENERATORS

Electrical plant in 1913:

1 Westinghouse, 1 phase, 60 cycle
3 Westinghouse, 2 phase, 60 cycle, 220 v.
21 Westinghouse, 1 phase, 60 cycle, 90 v.
2 Westinghouse, d.c. exciters, 250 v.
3 Stanley, d.c. generators, 600 v.
5 Stanley, 3 phase, 30 cycle, 2400 v.

35 generators and alternators

Electrical plant in 1917:

19 Westinghouse, 3 phase, 25 cycle, 4400 v.
2 Westinghouse, d.c. exciters, 250 v.
19 Westinghouse, 3 phase, 60 cycle, 4400 v.
50 General Electric, 3 phase, 25 cycle, 4400 v.
2 General Electric, d.c. exciters, 220 v.
3 Stanley d.c. generators, 600 v.

95 generators and alternators

The new generator layout had some unusual features. (See HAER drawing, sheet 4 of 8) All of the 25 cycle generators were grouped at the eastern three-quarters of the plant; the much smaller number of 60 cycle machines were mainly at the extreme western end. From penstock unit 62 through unit 73, however, both 25 and 60 cycle alternators were placed on the same shaft. Which of the alternators were placed on load depended on whether the Union Carbide Company needed more 25 cycle or more 60 cycle power. Also, when the power of the 60 cycle units at penstocks 74 through 80 were not needed, they were used to drive the 60 cycle machines on shafts 62 through 73 as motors, thus increasing the power input to the 25 cycle alternators on those shafts. The Stanley d.c. generators used for street car service were placed on extended shaft under a similar arrangement at penstocks 46 through 48, the d.c. exciters at 41 and 45. (See HAER photo 89)

The switchboard arrangement at the reconstructed plant was, in some ways, similar to that proposed by Thomas in 1902. In order for the plant to be conveniently controlled by one man, the switchboards were made unusually narrow. A control panel for a typical generator in the early twentieth century could be as much as 24 inches wide; those designed by Westinghouse especially for the "Soo" plant were 9 inches wide. A panel of this width was made possible by mounting the rheostats, which controlled the direct current fed to the field coils of the alternators, and the oil switches, which put generators on line or took them off, a convenient point on the extension of the switchboard gallery. Remote electrical (solenoid) switches were used to operate the accessories.[7] Four sets of bus bars were installed; two for the east end of the plant and two for the west end. Thus each generator could feed into one of two bus bars. A short circuit in any single bus bar would only shut down a portion of the plant. All of these features -- the use of remote switches to control the rheostats and circuit breakers, the very narrow switchboard for one man control, and the use of multiple bus bars -- were elements in Thomas' original switchboard design, forgotten after 1903. (See HAER photos 90 through 93)

The manufacture of the narrow switchboards gave some trouble. When Davis visited Pittsburgh to inspect the first shipment, he found the front of the panels in good shape, but in the rear the wiring and exciter bus bars were too crowded, even dangerous. Westinghouse engineers acknowledged the faulty workmanship:

> . . . fully realizing that the shop work was not up to the usual standard, which is accounted for by the fact that this is an unusual board of special design with extraordinary space limits, to which the workmen were not accustomed . . .[8]

Davis described the workmanship on the panels after the earlier defects had been corrected as "beyond our expectation" and congratulated Westinghouse on the neatness of the job.[9] The manager of the switchboard department of Westinghouse, Stremer, considered publicizing the switchboard arrangement at the "Soo". Writing to plant superintendent Dawson in late 1917 he stated:

> I feel that your installation at the Soo represents such a novel and exceptionally arranged switchboard equipment that the Westinghouse Company would very much like to prepare an article descriptive of the plant . . .[10]

Stremer even paid a visit to the "Soo" to secure information and photographs for a description which was to appear in Electrical World.[11] A search of that periodical failed to locate the article. Presumably it never was published, perhaps because the power company tended to shy from publicity and Union Carbide was reluctant to release any technical information about the carbide manufacturing process.[12]

At approximately the same time the additional turbines and generators and the new switchboard were being installed, Union Carbide made massive changes in their furnace arrangements. The rows of Horry rotary furnaces were replaced (See HAER photo 94 and HAER drawing, sheet 5 of 8) by large tapping furances which consumed 10,000 to 20,000 h.p. apiece. One of these furnaces was originally installed on the second floor of the power house, another was placed in a separate furnace building constructed on the grounds east of the power house around 1916. Eventually the second floor of the power house was used for cooling and storage purposes only.

COMPENSATING WORKS EXPANSION

Expanding the turbine, generator, and furnace plant in the power house would, of course, have been a useless extravagence unless additional water to drive this equipment was diverted from the St. Mary's River. Davis had estimated in 1905 that the water being diverted (c. 10,000 c.f.s.) was sufficient to drive only about 25 penstock units at full capacity.[13] Fortunately for the new owners of the power plant, legal matters in the rapids cleared up just at the point they assumed control.

The terms of the lease worked out between the Corps of Engineers and the power company in early 1913 have already been outlined. The 25,000 to 30,000 c.f.s. of water which this lease allowed to be diverted from the St. Mary's was, of course, contingent on the construction of additional compensating works and improvements in the power canal intake. The compensating works under consideration in 1913 consisted of 6 compensating gates, in addition to the 4 already erected, and a long dike. The 6 gates were to extend across span 8 and half of span 7 of the International Bridge; the dike was to run from the middle of span 7 and across spans 6 and 5 to the west end of the government dike.[14] Recognizing that under the 1909 treaty with Canada the diversion of water from the St. Marys and the form of the compensating works would have to be approved by the International Joint Commission, an application was filed with the I.J.C. for diversion in the summer of 1913.

In late 1913 and early 1914 negotiations and talks were conducted with Canadian engineers on the proposed works. Several Canadian engineers objected to the company's plans. The Canadians feared that if, at some point, both the Michigan and Canadian power canal had to be shut down simultaneously, the 10 proposed gates would not be able to discharge a sufficient quantity of water and the level of Lake Superior would be raised. They favored the erection of 19 compensating gates to insure that this would not happen.[15]

In February 1914 Davis, the company's consultants Noble and Woodard,[16] and the Army's District Engineer, Mason Patrick, met with 9 Canadian engineers to iron out their differences. At the meeting a compromise was worked out between the two parties. The number of compensating gates was increased from 10 to 16, with the Canadians agreeing to construct the 4 immediately adjacent to the existing works. Michigan Northern agreed to construct the other 8 plus the dike needed to completely close off the rapids for the U.S. government.[17]

The International Joint Commission held an open, public meeting at Detroit on March 9, 1914, to consider Michigan Northern's application for diversion.[18] But since Canadian and American engineers had reached an acceptable compromise the issue was in little doubt. The Commission's report, issued May 26, 1914, gave permission for the increased diversion as the additional regulatory works were constructed.[19]

In order not to obstruct the flow through the rapids more than absolutely necessary the 8 American compensating gates were built 4 at a time. The procedures used in their construction were substantially the same followed in 1901-1902. Coffer dams were built, towed into place, sunk around the location. The water was pumped out, and the work on the sub-structure began. The contractor for all 8 American gates was the Great Lakes Dredge and Dock Company. They began work September 1914 on the first 4 new gates (numbers 9-12), completing the contract in September 15. They then removed the coffer dams from the first site and moved immediately south to begin work on the second group. Sub-structure work on gates 13-16 ran from September 1915 to July 1916.[20] (See HAER photos 94 through 100 and HAER drawing, sheet 8 of 8)

The form of the new compensating gates was almost identical to that of the 1901-02 gates.[21] The dimensions of the vertical gates and the masonry piers were the same. The only major change was in the width of the sills. The 8 gates on the Canadian side of the border, including the 4 original gates, have sills approximately 40 feet wide. The sills on the 8 American gates are much wider, around 52 feet. The reason for this difference was probably the discovery during foundation excavation that the rock under the location of the American gates were badly undermined by a mud seam. To avoid possible foundation problems, the area beneath the sill was excavated deeper than anticipated and a concrete cut-off wall was poured. The sill was also extended in order to give the gates broader base, so that the water pressure exerted against the gates would be distributed over a wider area.[22]

The Penn Bridge Company was the contractor for the super-structure on all 8 units. They installed the movable gates and operating machinery between July 1915 and August 1916. The Canadians were somewhat later in beginning and in finishing their 4 gates. Construction on these was begun in June and completed in December 1918, more than 2 years after the 8 American gates (See HAER photos 101 and 102)

By 1919 the entire channel of the St. Mary's River had been closed off with the exception of a short gap above span 5 of the International Bridge between the government power canal dike and the abutment of compensating gate 16. (See HAER drawing, sheet 8 of 8 and HAER photo 102) Work was postponed on this portion of the works because the existing structures were more than sufficient for the waters being diverted by the American and Canadian power canal. By 1920, however, plans were being made to enlarge the Canadian canal. Thus the Corps of Engineers ordered Michigan Northern in February of that year to draw up specifications for the dike across span 5.[23] These were drawn up and approved by the War Department by late spring, but the bids received were too high. The Corps gave Michigan Northern permission to delay the work for another year.[24] A contract for constructing a small temporary dike (4 feet wide on top) was awarded to George O. Comb of the "Soo" in the summer of 1921. He began work on July 23. By August 14th the last remaining section of open channel in the St. Mary's at Sault Ste. Marie had been closed off, and by September 9, 1921, Comb had completed his contract.[25] (See HAER photo 103 and HAER drawing, sheet 8 of 8) In the summer and fall of 1922 the small dike constructed by Comb was significantly enlarged (to 10 feet wide at the top) and raised (an additional 4 feet).[26]

The 1913, lease had also required MLSPC to make alterations to the intake to eliminate possible cross currents due to increased velocity of flow into the canal. This was done by dredging in 1914. The intake at its mouth was deepened from 20 to 30 feet, and the bottom sloped upward to a depth of 20 feet at about 250 feet inside the harbor line.[27]

While Michigan Northern did not complete all of the promised works until 1922, the Corps of Engineers gave the company permission to increase flow to 17,500 c.f.s. in September of 1914 and to 21,500 c.f.s. in December of the same year.[28] This was increased to 25,000 c.f.s. in early 1916.[29] The plant was pushed to full design capacity (30,000 c.f.s.) only in July 1917 after the long-delayed repairs to the power house were made.[30]

POWER HOUSE REPAIR

Within months of Union Carbide's "purchase" of the power house there were indications that comprehensive power house repairs were under consideration. No definite moves in that direction were made, however, until April of 1915. Then two more consultants -- R.D. Johnson and Silas Woodard -- were asked to make yet two more studies of the power house and methods of remedying its deflection and leakage problems.

We were unable to locate any biographical information on R.D. Johnson. Silas Woodard, the other consultant, was born in Minnesota in 1870 and educated at the University of Michigan. His first important post was as an assistant engineer, Isthmian Canal Commission, between 1899 and 1902 and as resident engineer on the Pennsylvania Railroad tunnels between 1902 and 1909. In 1909 he had become a junior partner with Alfred Noble in the firm of Noble & Woodard, Consulting Engineers. He was, of course, familiar with the Sault Ste. Marie power plant and its problems through the studies he and Noble had made of lake regulation and compensating works for the company between 1909 and 1913. In 1914 Woodard had set up a practice of his own, specializing in power development, dams, tunnels, and pneumatic caisson foundations.[31]

Johnson delivered his report to the company first, in July of 1915. He proposed paving the forebay to around 130 feet from the power house with 1.5-foot thick reinforced concrete. This paving was to be supported on 5000 inclined piles driven to bedrock and tied into the power house at the tail race walls by steel rods. In front of the reinforced concrete forebay floor a reinforced concrete dam, 5 feet thick, was to be constructed between steel sheet piles to keep water from under the forebay floor. Sheet piling was to be run into the forebay embankments and in the embankments around to the ends of the power house. Under the concrete forebay floor several layers of graded gravel were to carry any leakage into a drainage and inspection chamber formed at the point where the concrete forebay floor met the power house. The water collected in this chamber was to be discharged through the end spillways. The cut-off dam and concrete forebay floor in Johnson's scheme were designed to eliminate the leak problem; the inclined piles beneath the forebay floor tied to the power house through the reinforced concrete were to counter-act the deflection.[32] (See HAER drawing, sheet 7 of 8)

Woodard delivered his report to Michigan Northern in September 1915.[33] In the report he examined and criticized all of the previous plans for power house improvement and then offered two of his own. One of his reinforcement schemes, similar in conception to von Schon's recommendation in 1903, contemplated the installation of concrete buttresses at the rear of the power house. There were to be 38 of them, 6 feet thick, 48 to 60 feet long, anchored to bedrock, and connected by a smaller buttress to the north power house wall. One would be placed at every other tail pit wall; all would be sunk pneumatically. This construction would have solved the deflection problem. The forebay leak was to be eliminated by driving a row of steel sheet piling to bedrock 3 feet in front of the power house. The material between the sheet piling and the power house was to be excavated to a depth of around 15 feet. This would then be filled with concrete. Steel rods would connect the steel pile cut-off wall to the forebay wall through the concrete.

Another option outlined by Woodard involved the use of 18-inch diameter cast iron batter (inclined) piles driven to bedrock at a 45^{o} angle by hydraulic jacks through holes made in the tail race floors. Woodard's plans called for 6 of these batter piles arranged in pairs in each of the 81 penstocks. At the points where they were to be installed the concrete in the tail race floor and lower walls would be removed. After the piles had been forced to bed rock and filled with concrete, a steel I-beam was to be placed across the top of each pair, extending across the tail pit and under the tail pit walls. After the I-beam was placed, the floors and walls would be restored to their previous dimensions by concrete filling. In this scheme, as in Woodard's masonry buttress scheme, steel sheet piling and a concrete apron were to eliminate the leak problem. (See HAER drawing, sheet 7 of 8)

Woodard's report was studied at some length by Davis, now chief engineer and general maanger of Michigan Northern, as well as other company officials. They decided to give his cast iron batter piles a try. Woodard was retained as a consultant for the work.[34] In order to test the feasibility of the idea and to gain a concrete estimate of the costs it was decided to install an experimental set.

The batter pile plan adopted differed slightly from that originally outlined by Woodard. Instead of 6 batter piles being driven beneath the floor of every tail pit, there were to be two rows of 5 piles on either side of every other tail pit wall.[35] The contract for a trial set of these buttresses was awarded to the Underpinning and Foundation Company of New York in mid-February 1916.

The Underpinning and Foundation Company began moving their equipment into the "Soo" in late March. By early April 1916 one of the tail pits (no. 73) had been drained, and by late April holes had been cut in the floor and driving had begun. There were problems from the start. Difficulty was encountered in driving the first pile because of interference from existing foundation piles. The first pile was eventually driven 8 feet, but attempts to drive it further failed.[36] Davis wired Woodard:

"Progress and expense of present work indicates we should adopt other methods".[37] A second pile was, nonetheless, driven in early May. By the 9th it had struck hardpan at about 3 feet above bedrock and could not be driven faster. Davis and Woodard, after consultation, decided that the better pile method might not work, would definitely be very expensive, and should be abandoned.[38]

The failure of the batter pile scheme led to a revival of the Davis-Lindenthal inclined cylindrical buttress plan. The Underpinning and Foundation Company, contractors for the batter pile trial, were asked to consider the alternate scheme, but they were not enthusiastic about taking up the project.[39] The Foundation Company of New York, however, was interested, and on June 5, 1916, signed a contract with the Michigan Northern Power Company to install 40 cast iron buttresses at the rear of the power house on a cost plus fee basis.[40] They estimated the cost of the work at around $250,000.[41]

The plans worked out by the foundation Company for buttressing the power house with inclined cast iron cylinders differed somewhat from Davis' earlier plans. Davis had contemplated cutting out the bottom portion of every other tail race wall near its northern end and a portion of the foundations so that the buttresses would butt directly against the power house. To avoid having to work at close quarters in a coffered-off tail pit and to avoid having to carry out a large amount of masonry destruction and repair, the Foundation Company worked out a different system in conjunction with Davis. The top of the inclined buttress would not butt directly on existing walls. Instead the top of the buttress would just rise above the outer edge of the power house foundation. The tail pit walls would then be extended to the end of the foundation apron. These extended tail pit walls, or piers, would transmit stressed from the power house to the buttresses. The buttresses, being anchored in bedrock, would resist the stresses and hold the building stable. To resist the tendency of an inclined buttress to move upward when horizontal pressure is exerted against it, a reinforced concrete arch bridge, 18 feet wide, was run from extended pier to extended pier across the entire rear of the power house.[42] (See HAER drawing, sheet 7 of 8)

One of the big advantages of the modifications made on Davis' plans, beyond ease of construction, was that it did not require shutting down any of the turbines for more than a few hours. A turbine was shut down only when the Foundation Company, operating from a floating plant, was setting and securing with timber piles and struts the cylinders from which the buttresses were driven.

The cylinder was set in place on the concrete foundation apron which extended beyond the tail pit walls of the power house. On the top end of the cylinder, once it was secured in position, an air lock was mounted. At the lower end of the cylinder was a "y". One leg rested on the foundation apron; the other was cut off on a horizontal plane at the level of the river bed. This device, about to be lowered into place is illustrated in HAER photograph 104.

Within the 5 foot 8 inch diameter cylinder a "shield" some 7 feet long and 5 feet 7½ inches in diameter was assembled. As this "shield" was driven down into the river bottom by jacks, the 1 foot 9½ inch segments of the 5 foot 6 inch diameter cast iron buttress were assembled. Every time the shield was driven 1 foot 9½ inches into the river bed, another segment was added to the buttress. Excavation in front of the shield, jacking forward the shield, and erection of the cast iron buttress segments continued until the shield reached solid rock. After penetrating bedrock for a distance of 6 to 12 feet a chamber was belled out beyond the shield with drills and small charges of dynamite. Then the shield and the buttress were filled with concrete. The cylinder and air lock were removed from the upper end of the buttress and moved on to another location. A wooden coffer dam, that served also as the form for pouring the concrete for the connecting pier, was then driven around the upper end of the buttress. The water was pumped out of the form and the concrete piers or tail pit wall extensions were then poured. After adjacent buttresses had been constructed and the tail race wall extensions poured, a reinforced concrete arch bridge was run from pier to pier. These operations occurred in front of every other tail pit wall. (See HAER photos 105 through 108)

The contract for buttress construction was signed with the Foundation Company on June 5, 1916. The company quickly moved a large floating plant to Sault Ste. Marie, including equipment to drive 10 buttresses simultaneously. Work got off to a slow start. This was not surprising since the type of construction contemplated was, in the words of Engineering Record, "a combination of caisson, tunnel and cofferdam methods unique in the history of American contracting."[43] The first buttress, number 37, took 43 days to complete. The Foundation Company also encountered labor problems. The "sand hogs" who were to work within the pneumatic cylinders struck for higher wages, so work was delayed while the Foundation Company recruited Negroes from St. Louis to replace the strikers.[44] Things speeded up by late summer as the construction crews gained experience. The buttresses were, by then, being driven in an average of 24 days. Because Union Carbide was in need of maximum power[45] (perhaps because of the demand for acetylene produced by the war in Europe) work was carried on day and night, and in October, in order to further accelerate construction, bonuses were offered for faster work. The last tunnel was concreted on December 29, 1916.[46]

As the Foundation Company finished constructing the inclined buttresses, Michigan Northern constructed the coffer dams for extending every other tail race wall over to and round them. And as the piers were completed the 18 foot wide concrete arches connecting them were poured, with gravel placed between the arches to add more weight to the top of the buttresses. This work lagged considerably behind the buttress work. By January 24, 1917, only 14 piers had been concreted, and work slowed down considerably during the late winter months. In the spring and summer of 1917, however, the work was pushed vigorously. By August 21, 1917, the last arch had been concreted and gravel loading the entire bridge had commenced. (See HAER photo 108) With the completion of the loading bridge in September 1917, the reinforcement of the power house against sliding was accomplished.[47] The fears of structural stability which had kept the plant operating at only a 14 foot head almost 15 years were removed.

Forebay leak repair, the remaining problem area, was not included in the mass of reconstruction and plant improvement work undertaken in the first 5 years of Michigan Northern's ownership of the power plant. The 1910 repairs seemed to be holding and Union Carbide, in the midst of heavy war-time demand for their product, was probably reluctant to shut down operations for this work.

The effect of the repair and expansion program can be seen in plant output. As the chart on the next page indicates, the average power output, which had been only slightly above 10,000 h.p. between 1911 and 1913, had jumped to around 32,000 h.p. by 1917. Full design capacity, 40,000 mechanical horse power, was first achieved on an annual average in 1919. The era of troubles was over; the era of relative stability had begun.

OTHER REAPIRS AND IMPROVEMENTS

While compensating works expansion, power house repair, and additional turbine and generating equipment were the most critical projects undertaken by the Michigan Northern Power Company between 1913 and, say, 1920, there were a number of other much needed repairs carried out. For example, all along the canal there were sections where the banks had collapsed and slid into the channel, impeding the flow of the water. Problems were particularly acute in the rock section where over 1000 feet of wall were in need of repair. This wall was carried out in 1916 and 1917 by the Foundation Company, the contractors for power house reinforcement.[48] (See HAER photos 109 and 110)

Some consideration was given to making more than mere patchwork corrections to the canal. O.M. Jones, the plant superintendent, was asked by Davis to investigate the possibility of deepending or enlarging the width of the channel in 1918. Jones' studies, however, indicated

TABLE 17:

Average Annual Output in horse power and kilowatt hourse of the Michigan Lake Superior Power Company hydroelectric plant (after 1913 the Michigan Northern Power Company hydroelectric plant), from 1903 through 1935

Year	Number of units operative	Average annual output in horse power	Total station output in millions of KWh's
1903	10-31	900	0.5
1904	31	7300	48
1905	31	7300	48
1906	31-32	9800	64
1907	32	9400	61
1908	32	9600	63
1909	32	6600	43
1910	32	7300	48
1911	32	10300	68
1912	32	10800	70
1913	32-33	10900	71
1914	33-42	12700	83
1915	42-50	17800	117
1916	50-70	20000	131
1917	70-78	33900	221
1918	78	35700	233
1919	78	40400	264
1920	78	39300	258
1921	78	39500	258
1922	78	37700	246
1923	78	40100	261
1924	78	39400	259
1925	78	38600	253
1926	78	33000	149
1927	78	41500	271
1928	78	41200	270
1929	78	39400	257
1930	78	42400	278
1931	78	28200	183
1932	78	22900	149
1933	78	19700	129
1934	78	38500	252
1935	78	42000	274

Note: All figures approximate

that this would not be economically justifiable and complemented the plant's original designer on his choice of dimensions:

> . . . I would say that the designers of the canal seem to have arrived at the economical dimensions beyond which enlargement in any direction would be unprofitable. Any decrease in the canal slope, to be made at a reasonable cost, must be sought in the direction of removing the accumulations of litter and debris resulting from wall failures, and restoring damaged walls and timbered slopes to their original condition.[49]

The ice and trash rack also came under serious study during the period of intensive remodeling work on the plant. During the great February 1903 washout von Schon's original rack had been seriously damaged by the sudden precipitation of ice. He repaired it and reinforced it with a number of additional A-frames.[50] This rack operated well when only small quantities of ice and trash were involved, but it proved inadequate for large quantities. Ice tended to accumulate on the racks and block the passage of water until water pressure threatened to overturn the structure. To avoid this problem the lower racks were usually removed during the winter. (See HAER photo 111) This allowed some ice to dive under the remaining racks and get into the penstocks.

R.D. Johnson, one of the consultants asked to study power house reinforcement, was also asked to investigate the problems of ice and trash protection in 1915. Johnson, in general, felt that von Schon's design was "a good one to follow, and that merely remodeling" would do much toward solving the problem. He suggested using only very course grating on the rack, so that its primary function would be stopping large floating debris. The fine trash racks, he felt, should be placed at the entrance to the penstocks. As further protection Johnson proposed enlarging the size of the ice chute and narrowing the angle of the rack. The new chute would lead into penstock 48, instead of 43. A permanent floating log boom was to provide additional protection behind the modified rack. Finally, Johnson suggested converting the two end penstocks (1 and 81) into ice and trash runs for floating debris collected naturally at the ends of the forebay.[51]

There is some evidence that the power company contemplated adopting Johnson's scheme. Penstocks 1 and 81, for example, do not have turbines. Experiments were also carried out on trash racks placed either at the entrance of the penstocks or in the penstocks themselves. But these racks were never installed throughout the plant on a permanent basis because of expense and because they caused a loss of head varying from

.031 to .095 feet.[52] Some experiments were also conducted on a trash cage which completely surrounded the turbine draft cases. But these tests, too, led to no permanent installation.

As a result the old trash rack in the forebay continued to occupy a prominent position at the power house. It did undergo some major alterations and repairs, however. In the spring of 1916 the intake boom broke, huge chunks of ice entered the canal, smashed the ice rack, and clogged the turbines. Described by Dawson, the plant superintendent, as "the worst condition we have faced since the plant was built"[53] (an obvious exaggeration), this accident so damaged the ice and trash rack that a brief plant shut down was required in 1917 to repair the damage.[54] (See HAER photo 112)

At the same time that investigations on ice and trash protection were underway, Michigan Northern made a number of other additions to the plant. The headgates, for example, were equipped with electric motors and enclosed in little "box-like" houses placed on top of the gate's superstructure.[55] Lombard governors for turbine speed control were placed on all units in 1916 or 1917.[56] (See HAER photos 113 and 114)

Changes were also made in the penstock gate arrangement. These gates were to close off the upstream ends of the penstocks when repairs or adjustments to the turbines were needed. Von Schon had planned for these gates to consist of interchangeable timber frame section about 16 feet wide and 6 feet high. Three of these sections would be lowered into gate post recesses set at the upstream ends of the penstock partitions to close off a unit. These sections were to be raised and lowered by an electric crane travelling device placed on the ledge where the penstock partions projected beyond the power house.[57] Such a unit had not been installed in 1904, and a manually-powered travelling derrick was used for installing or removing the penstock gate sections. (See HAER photos 82 and 84) Around 1915, however, an electrically-operated gate hoist and one-piece steel-web penstock gates were installed.[58] (See HAER drawing, sheet 6 of 8)

Additions to the plant, efficiency investigations, experiments with better means of ice and trash disposal continued up until approximately the end of World War I. Then, as the demand for acetylene (and hence calcium carbide) tailed off, the era of expansion came to an end. The company became steadily more reluctant to put any more money into the plant. Davis, for instance, wrote to Michigan Northern engineer C.M. Jones in 1921 noting that it was the policy of the company to curtail expenses to as large a degree as possible at present.[59]

CHAPTER VII: Footnotes

1. "Report of Charles D. Warren andClarence M. Brown, Co-Receivers, to the first Mortgage Bondholders of the Michigan Lake Superior Power Company and the Board of Directors of the Lake Superior Corporation." April 29, 1908 (vf 1-129)

2. Electrical World, June 20, 1908 (vf 27-1)

3. Sault Evening News. November 10, 1908 (vf 27-4)

4. "Memorandum Respecting the Michigan Lake Superior Power Company," (vf 28-6) p. 12

5. L.H. Davis to C.D. Warren, May 1, 1909 (Mf 24112)

6. "Agreement Between the First Mortgage Bondholders and the Lake Superior Corporation," (vf 28-7)

7. C. Brown to F. Taylor, May 19, 1910 (vf 27-39)

8. W.C. Franz to F. Taylor, May 25, 1910 (vf 27-39)

9. "Decree of Foreclosure - The Real Estate Trust Company vs The Michigan Lake Superior Power Company," (vf 192-194) p. 133

10. "Sixth Report of the First Mortgage Bondholders Committee - Plan of Reorganization, April 10, 1913," (vf 27-0)

11. Sault Evening News. April 11, 1913 (vf 27-15)

12. Ibid. April 11, 1913 (vf 27-14)

13. "Application of Clarence Brown to the International Joint Commission, June 27, 1913," (vf 165.3.2-1) p. 7

14. Ibid. p. 3

15. Ibid p. 4

16. Ibid. p. 4-5

17. "Treaty Between the United States and Great Britain - Boundary Waters Between the United States and Canada, May 13, 1910," Articles VII & VIII, (vf 13-159) pp. 7-8

18. "International Joint Commission Meeting at Ottawa, Dctober 7, 1913," (vf 165.3.4-16)

19. "International Joint Commission Order of Approval, May 26, 1914," (vf 9.1D)

20. "Water Lease between the Department of War and the Michigan Northern Power Company, May 28, 1914." (vf 9.1D-2)

Chapter VII, Part 3

1. O.B. Holley to Davis, May 24, 1941 (Jf 14.D).

2. Ibid., and Davis to Trump Manuf. Co., May 22, 1913 (vf 162.6-1)

3. "Further Statement by the Michigan Northern Power Company in Regard to Power Situation at Sault Ste. Marie, Michigan, September 12, 1941," pp. 10, 13 (Jf, Box, 1)

4. This was also due to the fact that the plant developed a higher head than the 16 ft. von Schon had relied on in making his early calculations. In his 1904 General Report he noted that there were no reliable hydraulic slope formulas for a canal of the dimensions contemplated and that, therefore, his assumption of 16 feet might be conservative. "There is a strong probability," he noted, " that the effective head will be in excess of 16 feet, it may be 17 or even 18 . . ." (p. 38). The average head at the power house after all reapirs were made was 17 to 18 feet.

5. N. de C. Walker to Dawson, January 13, 1928 (Ef 92); Dawson to Jones, July 27, 1928 (Ef 92)

6. Holley to Davis, May 24, 1941 (Jf 14.D)

7. Davis to I.R. Edmands, April 28, 1913 (vf 169a-17); Edmands to Davis, April 29, 1913 (vf 169a-19)

8. Dawson to Davis, October 18, 1913 (vf 169a-218)

9. Dawson to C.C. Owens, May 3, 1916 (Misc.f 22)

10. Dawson to Davis, December 5, 1917 (vf 155 226½)

11. Ibid.

12. E.F. Price to Davis, June 8, 1915 (vf 147-44): "We do not like to give publicity on voltage, phase and frequence of our power and generally do not like publicity of this kind." (referring to a proposed Westinghouse circular)

13. Davis to Warren, February 13, 1905 (vf 165.0.2-11) telegram.

14. Davis to Noble and Woodard, April 24, 1913 (vf 165.3.1-16); "Application of Clarence M. Brown, Receiver . . .," June 27, 1913 (vf 165.3.2-1) See also the map in vf 165.3.1-19½

15. Davis to Noble and Woodard, October 11, 1913 (vf 165.2.2-363); J.L. Allison to Thomas Gibson, October 6, 1913 (vf 165.2.2-374); Davis to Noble and Woodard, December 4, 1913 (vf 165.2.2-376).

16. Noble and Woodard to Oavis, December 8, 1913 (vf 162.2.2-378), for calculations on the probability of both canals being closed and high water occurring silumtaneously.

17. Davis to B.F. Price, February 24, 1914 (vf 165.2.2-406); Mason Patrick to Davis, March 12, 1914 (vf 165.3.14-8); Davis to Sabin, May 1, 1914 (vf 165,3,14-29)

18. For a report on the March 9 hearing before the I.J.C. see "Proposed Dam of the Michigan Northern Power Co., at Sault Ste. Marie," Water Chronicle, v. 3 (1914) p. 178

19. For the May 26, 1914, I.J.C. report see "Lake Superior to be Regulated," Water Chronicle, v. 4 (1914) pp. 104-08.

20. Davis to L.F. Harza, February 18, 1918 (vf 165.1-42).

21. Invitation for Bids; Specifications for Compensating Works, both dated July 28, 1914 (vf. 165.4-60; vf 165A-141)

22. Davis to Patrick, June 28, 1915 (vf 165.4-239).

23. E.M. Markahm to Michigan Northern Power Company, February 11, 1920 (vf 165.6.1-19).

24. Jones to Markham, July 16, 1920 (vf 165/6/3-40); Markham to Michigan Norhtern Power Company, August 5, 1920 (vf 165.6.3-46).

25. Jones to Davis, September 26, 1921 (vf 165.6.4-34).

26. see vf 165.6.5 for information on the enlargement of the dike in 1922.

27. see vf 164.2.

28. Patrick to Michigan Northern Power Company, September 5, 1914 (vf 132-7); Davis to Patrick, December 8, 1914 (vf 132-21); Patrick to Davis, December 2, 1914 (vf 132-20).

29. Patrick to Michigan Northern Power Company, March 16, 1916 (vf 132-21).

30. F.W. Alstaetter to Michigan Norhtern Power Company, June 21, 1917 (vf 132-32); Alstaetter to Michigan Northern, June 30, 1917 (vf 132-35).

31. "Woodard, Silas H.," in Who's Who in Engineering, 4th ed., 1937, New York, 1937, p. 1539.

32. R.D. Johnson to Davis, July 10, 1915 (vf 222.2.9-19).

33. Report on Reinforcement of Power House at Sault Ste. Marie, Mich. made for Michigan Northern Power Company by Silas H. Woodard, September 10, 1915 (vf 222.2.8-29). Woodard compiles in a long series of apprendices all of the previous reports (except Johnson's) on power house repair.

34. Woodard to Davis, February 23, 1916 (vf 222.8.3-9).

35. Davis to Jones, February 23, 1916 (vf 222.8.2-7); Davis to Price, February 23, 1916 (vf 222.8.2-8).

36. Davis to Price, telegram, April 28, 1916 (vf 222.8.2-49).

37. Davis to Woodard, telegram, May 3, 1916 (vf 222.8.2-53).

38. Davis to E.F. Price, May 9, 1916 (vf 222.8.2-64) telegram; Davis to E.F. Price, May 10, 1916 (vf 222.8.2-70).

40. Foundation Company Contract, June 5, 1910 (Mf 49 51).

41. F. Remington to Davis, May 24, 1916 (vf 222.8.4-10); Davis to W.J. Knapp, May 23, 1918 (vf 222.8.4-149).

42. Davis to Woodard, June 12, 1916 (vf 222.8.3-25); Doty to Davis, June 8, 1916 (vf 222.8.3-24).

43. "Inclined Tunnels Buttress Power Plant," Engineering Record, v. 75 (1917) p. 292.

44. Davis to Woodard, August 14, 1916 (vf 222.8.3-44)

45. C.T. Ayres to Davis, August 29, 1916 (vf 17-654); E.F. Price to Davis, December 4, 1916 (vf 222.1-43).

46. "Inclined Tunnels Buttress Power Plant," Engineering Record, v. 75 (1917) pp. 292-96, provides the best description of the installation of the buttresses.

47. Davis to Woodard, August 22, 1917 (vf 222.8.7-107).

48. ? to Davis, August 11, 1916 (vf 221-6 to 221-8); F.W. Welgate to Davis, October 23, 1916 (vf 221-32); Davis to E.F. Price, October 17, 1917 (vf 221-101); Davis to E.F. Price, August 9, 1916 (vf 221-4).

49. Davis to Knapp, September 19, 1919 (vf 214-25); Jones to Davis, August 23, 1918 (vf 218-52) for the quotation.

50. von Schon, General Report, p. 26.

51. R.D. Johnson, "Report on Proposed Method for Ice Disposal," July 31, 1915 (vf 130-127).

52. Davis to Jones, May 2, 1919 (vf 220-1); Jones to Davis, November 25, 1919 (vf 218-128); Jones to Davis, April 22, 1921 (vf 218-148).

53. Sault Ste. Marie Evening News, May 1, 1916.

54. Davis to E.F. Price, October 2, 1917 (GL-2, 19, 303-05); Davis to S.T.Handy, September 24, 1917 (GL-2, 19, 280).

55. Davis to Knapp, February 5, 1918 (vf 194.3-153).

56. see vf 46.

57. von Schon, General Report, pp. 27-28.

58. Dawson to S. Morgan Smith Co., January 29, 1915 (Misc.f 110) and other correspondence in the same file.

59. Davis to Jones, May 28, 1921 (vf 218-149).

CHAPTER VIII:

EPILOGUE: THE POWER HOUSE AND POWER CANAL AFTER 1920

After 1920 the power plant reached an era of stability, an era when changes were few and far between. One of these changes, however, came rather early. In 1926 the forebay again gave way.

On Friday, August 13, 1926, a leak was noticed opposite penstocks 63 and 64 on the north side of the building. It had been observed two or three days previously by tourists fishing from the loading bridge installed at the rear of the power house during the 1916-17 reinforcement work. But not realizing what the muddy water they saw signified they had not reported it. By August 14 water was bubbling up 6 to 8 inches and another leak had broken out opposite penstocks 52 and 53. On August 16 another leak was discovered, this one opposite penstock 48. The plant superintendent, Dawson, had begun to lower the head at the power house shortly after discovering the first leak. With conditions rapidly deteriorating he and Davis decided to shut down the plant to make the long-delayed premanent repairs in the forebay area.

During the shutdown a continuous row of interlocking steel sheet piles was driven to bedrock 9 feet in front of the forebay wall, at the upstream edge of the power house foundation. (See HAER photos 115 and 116) These piles were cut off so that they projected 4 feet above the forebay floor. The piles were tied to the power house with tie rods, and the area between the piles and the forebay wall was sealed with reinforced concrete, clay refill, and a modified forebay apron.

The old forebay apron had consisted of 2 layers of 2-inch planking on 12-inch sills run at an inclined up to the penstock floor. The new apron was inclined only for a short distance. At the height of the tops of the steel piles, the incline ended. The apron was brought to the forebay wall on the level, intersecting it 6 feet below the penstock floor. The new apron had 6-inch groove and spline planks instead of several layers of 2-inch planks. This planking was placed on 12" x 12" sills spaced 5 feet 6 inches apart. (See HAER drawing, sheet 7 of 8)

At the same time the sheet piles were being driven, the entire forebay floor was taken up, refilled with clay, and replanked. Left over clay was piled on the completed forebay apron as an extra precaution, and to avoid the problem of having to haul it away. (See HAER photo 117) The voids created beneath the power house by the leak were refilled by clay ramming.

The shutdown which the washout brought gave Michigan Northern an opportunity to make other repairs as well. The ice and trash rack, for example, was in poor condition once again. It was completely rebuilt, and the ice chute was reinforced.

The power canal also required repairs. In the intake there were two 250 foot long gaps on either side of the canal that were unlined. These gaps had been created when the old upper intake coffer dam had been dredged out in 1902 or 1903. Timber cribs were constructed and these gaps filled. The entire canal was cleared of debris, a gigantic task. Some 35,000 tons were removed. Repair crews, at the same time, remedied bulges and breaks in the canal walls and coctored the headgate aprons.[1]

Water was let back into the canal on December 13, and by December 16 the plant was operating under a 20 foot head with no sign of a leak. But trouble had not quite ended. The sudden increase in the current flowing into the canal when the headgates were opened broke loose a large area of jam ice in the river channel. This floated into the power canal, creating the worst ice jam in the plant's history. Ice filled the penstocks and forebay area solid to the bottom. For 4 days all the available labor of both the Michigan Northern Power Company and Union Carbide were employed day and night. More than 1000 sticks of dynamite were used to break up the jam. Operations at the power house did not resume until December 20, 1926.[2]

The repairs made in 1926 were completely successful. Since that date the power house has never been shut down due to structural instability or foundation washout. It has been shut down since that time (without water being drained from the canal) by low water levels in Lake Superior and by anchor ice forming on and clogging the turbines. But these are natural phenomena which engineering has no means of controlling.

The only major change in the basic configuration and arrangement of the power canal and power house which occurred during Michigan Northern's tenure at the hydroelectric plant occurred in the 1940s. In the early 1940s the government decided to extend the southwest pier leading up the the St. Mary's Falls Canal. This extension would have all but completely blocked the power canal intake. Hence in the mid-1940s Michigan Northern had to massively alter the intake area. Much of the extreme western end of the southern intake area was dredged out. Where the old intake had pointed towards the northwest, the new intake pointed towards the southwest.[3] (See HAER drawings, sheets 1 and 2 of 8)

There were, beyond the major changes forced by washout or government action, only a number of minor changes carried out between 1920 and 1963. One was the extension of some of the rectangular waste gates 8 feet upward by the addition of rectangular cast iron tubes in a number of penstock units. These extensions were installed in some units in the 1920s as an aid in the removal of floating ice. Their numbers have been steadily increased until there are now approximately 25, with plans being currently made to add several more. Another minor change was the removal of the dormers from the east and west pavillion roofs during re-roofing undertaken in the 1950s. There was also a name change. In 1951 the Michigan Northern Power Company became the Carbide Power Company, without any real change in management or ownership.

There was occasional talk of making massive changes in the power canal and power house around 1940, as the date for the expiration of the 30 year water lease from the government approached (1944) and as the Corps of Engineers agitated for an enlarged power house in the rapids which would use all available water on the U.S. side of the border. Contemplated improvements included deepening and enlarging the whole intake section (and hence adding an additional gate to the headgates), moving the ice and trash rack closer to the power house, and replacing the 1901-02 Jolly-McCormick (Webster, Camp and Lane) trubines with newer models. Also suggested were the use of training piers in the forebay to direct water into the penstocks with less turbulence.[4] None of these improvements, however, were made. The anticipated overall improvement in plant output gained by such alterations usually compared unfavorably with costs, so the proposals were dropped as uneconomical.

For fifty years Michigan Norhtern (or Carbide Power) held the "Soo" power house, selling power to the adjacent Union Carbide plant, the largest in the United States. (See HAER photos 118 through 120) The two companies employed one quarter of the employable persons in Sault Ste. Marie and paid (in 1945) 37.58% of the city budget, 31.37% of city and county taxes combined.[5]

Originally the carbide produced at the Sault Ste. Marie plant was shipped all over the country. But gradually this changed. Because of the relatively isolated location of Sault Ste. Marie, and hence the high transportation costs, the "Soo" plant could not compete with other Union Carbide plants further to the south. By the early 1960s, 85 to 90% of the output of the "Soo" plant was being absorbed by one customer, Du Pont at Montague, Michigan. Because this customer was close and because shipments to Montague were in bulk, using lake freighters, it was possible to remain competitive. In 1961, however, DuPont announced that it intended to manufacture its own acetylene, extracting if from natural gas. Faced with the loss of the customer which absorbed the bulk of the output of the "Soo" plant, Union Carbide decided to close down these works.[7]

Union Carbide approached the Edison Sault Electric Company in early 1962 about purchasing the hydroelectric plant. Edison Sault was a local utility which, since the establishment of the government power house in the rapids in 1911, had been largely limited to leasing and distributing power. Agreement was eventually reached, and Edison Sault assumed control of the plant in May 1963.[8]

The changes made since Edison Sault assumed control have been relatively minor, with two significant exceptions. Because Edison Sault was concerned primarily with domestic power distribution, the bulk of the generating portion of the plant had to be converted from 25 to 60 cycles. Edison Sault carried out this work in 1963, installing a large number of new 60 cycle generators, as well as rewinding some of the existing units. Dispatch facilities were added since Edison Sault lines transmitted power to much of the eastern Upper Peninsula.

Another major change was the removal of the ice and trash rack from the forebay in the early 1970s. It had been recognized for decades that the trash rack cost the plant around 0.2 foot in head, besides being a continual burden in terms of cleaning, maintenance, and repair. Since the St. Mary's was no longer being used to float pulp wood, Edison Sault decided the rack was expendable, especially in view of the savings in head involved. The removal of the trash rack, of course, meant that the turbines were much more suseptable to damage from floating debris. The problem was most critical on the old Webster, Camp and Lane units at the eastern end of the power house. These had only 12 control gates, while the later units had 16. This meant that larger pieces of flottage could enter the Webster, Camp and Lane units and damage the runners. To lend some protection to these units grill work was placed around their control gates.

The hydroelectric plant constructed by von Schon between 1898 and 1902 is still operative. Some 60% of the electric power used on the eastern part of Michigan's upper peninsula is generated there. Not only is it still operative, but the plant remains in very good condition. In 1962 when Edison Sault was considering the purchase of the plant from Union Carbide they retained the Stone & Webster Engineering Corporation of Boston to report on the overall structural and hydraulic condition of the power plant. Stone & Webster's report[9] summarizes to a great extent the condition today (1978):

> Canal and Forebay:
> "Visual inspection of the timber section of the canal . . . indicates that the canal banks are generally in good shape." "The masonry wall capping the stone section likewise appeared to be in good shape . . ."
>
> Power House:
> "Careful visual examination of the tailrace face of the building and the buttressed platform showed no evidence of recent settlement cracks, thus indicating that the foundations are in a stable condition. Considering the length, age and foundations of the building, the exterior masonry wall was surprisingly free of cracks and other signs of settlement or deterioration due to age."

Turbines:
"The interiors of the casings and the draft tubes were in excellent condition, showing no sign of rust or pitting. The wicket gates also appeared to be in excellent condition . . ." "All runners were found to be in excellent operating condition." "It is believed that the excellent condition of units of this vintage was the result of continued maintenance . . ." "The noncorrosive condition of the Lake Superior water also may have been a major factor."

Penstocks:
"The concrete walls of the flume and floor were watertight and showed only minor cracking and spalling."

Steel Bulkheads:
"The stuffing boxes in the cases and in the bulkhead of the flume (penstocks) appeared to be in good condition and watertight." "The steel bulkheads, which form the end of the intake flumes were . . . free of rust and showed only a slight staining on the surface at the water line."

Overall Conclusion:
"We believe that the Carbide Power Company hydroelectric plant, although over 60 yrs. old, is in remarkably good condition . . ."

Not only does the plant remain in remarkable good condition, it is, despite its age, still an impressive engineering work. As the president of the James Leffel Company noted in 1971, it has the "most impressive line-up, of greater length and number of horizontal units, than we have ever encountered in one location heretofore".[10]

In 1904 von Schon wrote: ". . . I am confident good report will be made by future generations . . ."[11] The shadows of legal battles, financial problems, and faculty foundations which loomed over the works for over a decade must have made him dispair of ever hearing good reports on the greatest single project of his engineering career. The plant's present condition, however, is testimony to the durability and premancency of von Schon's designs. He may have made a mistake on the foundations, but the rest of the design was solid, and the one mistake he did made was correctable.

CHAPTER VIII: Footnotes

1. The bulk of available information on the 1926 repairs is in Ef 45; see also Sault Ste. Marie Evening News, August 16, 1926, November 18, 1926, and December 20, 1926. Additional information can be gained from blueprint no. 1085r, Folder 6, Pocket 1, Edison Sault drawing collection.

2. Davis to Jones, citing material written by Dawson, October 7, 1944 (Ef 45).

3. O.B. Holley to Jones, August 26, 1943 (Jf 6.2); Jones to Holley, March 20, 1945 (Jf 6.2); Jones to L.H. Davis, March 20, 1945 (Jf 6.2).

4. "Statement by Michigan Northern Power Company in Regard to Plans for Reconstruction of Power Facilities at Sault Ste. Marie by the War Department, for the Hearing at 2:45 p.m. March 3, 1941 at the Office of the Board in Washington, D.C.," pp. 8-10 (Jf, Box.1); "Further Statement by Michigan Northern Power Company . . .," Setpember 21, 1941, pp. 15-19 (Jf, Box 1).

5. "Statement by Michigan Northern Power Company," p. 11.

6. Sault Ste. Marie Evening News, December 18, 1945.

7. Ibid., August 1, 1962.

8. Carbide Power Company File (Ef).

9. "Survey of Carbide Power Company Hydroelectric Plant," September 7, 1962 (Carbide Aquisition Files Box, Edison Sault Electric Company Records).

10. J. Robert Groff, President, James Leffel & Co. to Edison Sault Electric Company, March 31, 1971 (Leffel Reference W 71-1144, stored in book case in power house next to dispatch room).

11. von Schon, General Report, p. 2.

BIBLIOGRAPHY

I. Archival Material

A. Letter Books and Report Books

Cloud Letter Book, 1 volume. Letters of F.W. Cloud, August 1, 1916 to February 17, 1919. Cloud was the assistant to the general manager of Michigan Northern Power Company.

Contracts, 1 volume. Handwritten copies of various contracts, c. 1896 to c. 1905. Specifications are not included with the contracts and only certain contracts are present. Coverage is by no means complete.

Davis Letter Book, 1 volume. Letters of L.H. Davis, February 14 to October 16, 1905. This volume contains only a few letters. Most of Davis' correspondence is found in the General Letter Books, Series 2. Why these few occur separately bound is not clear. Davis was von Schon's successor as chief engineer at the power house.

General Letter Books (GL), Series 1, 22 volumes. Letters of H. von Schon, August 16, 1896 to September 20, 1903. Von Schon was chief engineer of the hydroelectric plant project.

General Letter Books (GL-2), Series 2, 25 volumes. Letters of von Schon's successors as chief engineer, primarily L.H. Davis and Owen M. Jones. Many of these letters are duplicated in the vertical files.

Moore Letter Book, 1 volume. Letters of Charles Moore, April 3, 1903 to December 29,1903. Moore was an assistant to Cornelius Shields, President of the Consolidated Lake Superior Corporation.

Northern Industrial Power Company Letters, 1 volume. Letters from L.H. Davis to the Northern Industrial Power Company, 1915-1918.

Presidential Letters (PL), 7 volumes. Letters of von Schon to the president and vice-president of the Michigan Lake Superior Power Company, February 8, 1899 to October 2, 1903. Some of these letters also appear in the General Letter Books.

Receiver's Letter Book (RL), 1 volume. Letters addressed to the Receiver of the Michigan Lake Superior Power Company, July 9, 1904 to September 22, 1904.

Record of Switchboard Output, 4 volumes. Stored in the vault in the hydroelectric plant, these cover the years 1903-1913.

Reports, 5 volumes. Reports by von Schon and his assistant engineers between c. 1897 and c. 1903. These fall into two sets.

Set 1: 3 volumes numbered 1, 3, and 5 on the spine. These cover the following periods--volume 1 (March 16 to December 18, 1897); volume 3 (January 10 to September 1, 1901); and volume 5 (June 13 to December 11, 1902). The intervening volumes are missing. Much of the content of these volumes is duplicated in the General Letter Books.

Set 2: 2 volumes which we have arbitrarily designated as volumes A and B. These are not the missing volumes in Set 1. Volume A covers the period January 17, 1898 to January 27, 1899. The lable on the front of this volume reads "Specifications", but the volume has only one set of specifications. The bulk of the book contains reports by von Schon or his assistant engineers. Volume B has reports dating between June 6 and December 1, 1899.

Sault Ste. Marie Board of Supervisors and Common Council Proceedings and Ordinances (P & O), 1 volume. Proceedings and ordinances relating to the power canal April 21, 1886 to October 18, 1901.

Vice Presidential Letter Book, 1 volume, labeled "A". Letters of F.A. Clergue, vice-president and general manager (later president) of the Michigan Lake Superior Power Company. These letters date between August 31, 1900 and April 8, 1903.

Work Diary, 2 volumes. Daily diary of activities at the power canal for the years 1896 and 1897. The author is unknown; presumably the activities of each of the company's employees were filled in by anyone with time to spare.

B. Vertical Files

Daily Report Files (DRf), 3 drawers filed chronologically, covering the period c. 1904 to c. 1922.

Edison Sault Electric Company Current Files (Ef). These are kept in the new company offices. Only a few selected files were used, furnished at the request of the research team by Elgin Nixon.

Sam Finlay's File (Ff), 1 drawer containing correspondence dealing mainly with technical matters, filed by subject, dating from around 1940.

General Correspondence File (GCf), 1 drawer. Material in this drawer is filed by letter (A through Z), and covers primarily the period 1903 to c. 1920.

Horizontal Drawers, 9 drawers. Used mainly to file graphs, but including a number of miscellaneous reports from 1900 on.

Independent File (If), 1 drawer. File with materials relating to the Michigan Industrial Power Company, the Northern Michigan Railroad Company, St. Mary's Power Company, and Sault Ste. Marie Terminal Railroad Company, c. 1900 to c. 1920.

O.M. Jones File (Jf). 3 boxes of material filed by subject. Most of the material dates from the period 1930-1950. O.M. Jones was successively engineer, general manager, and vice president of Michigan Northern Power Company.

Main Vertical Files (vf), 19 drawers. Some 70% of the vertical files in the Edison Sault Archives relating to the pre-Edison Sault ownership period (before 1963) belong to one set. Materials in this set are filed by subject. There is a card file table of contents, but the material in this card file, as well as a number of the drawers, is scrambled up.

Manager's Office, Correspondence from, file (Mf), 1 drawyer. Primarily correspondence of and with the general manager of the Michigan Lake Superior Power Company in the period c. 1904 to c. 1910.

Miscellaneous Vertical Files (Misc.f), 2 drawers. These are labeled "Miscellanous". The contents of these drawers are in files arranged in no discernable order. Most of the material is correspondence with equipment companies daiting from the period c. 1910 to c. 1925, but with some letters from as late as 1950.

Old Correspondence File (OCf), 1 drawyer. Correspondence from the period c. 1898 to c. 1902, including von Schon's General Report of 1904.

C. Works in Vertical Files of Sufficient Length to List Seperately

"Further Statement by Michigan Northern Power Company in regard to the Power Situation at Sault Ste. Marie, Michigan, September 12, 1941" (Jf, Box 1)

"Statement by Michigan Northern Power Company in regards to plans for reconstruction of power facilities at Sault Ste. Marie by the War Department, for the hearing . . . March 3, 1941 at the Office of the Board [of Engineers for Rivers and Harbors]. (Jf, Box 1)

Schon, H.A.E.C. von. "Construction History Report", MS #1: Movable Dam History; Balance of Intake History; Canal Section I, II, and III; MS #2: Revetment Construction, Section II and III; Bridge Abutments. (OCf, von Schon Reports). Some handwritten notes outling the history of construction of the project. Many pages in these two note books are blank. In fact only a small portion of either note book has been used. These were apparently to form a part of a longer report. There is evidence that they were typed up, but the comprehensive "Construction History" could not be located.

Schon, H.A.E.C. von. General Report on plant of Michigan Lake Superior Power Company, July 1904, 64 pp. (OCf, von Schon Reports)

Woodard, Silas H. "Report on Reinforcement of Power House at Sault Ste. Marie, Mich. made for Michigan Northern Power Co., September 10, 1915" (vf 222.2.8-29). Woodard's comprehensive report on power house repairs. Woodard not only gives his recommendations, but in a series of appendices reprints the reports of Lindenthal; Davis; Herschel and Pringle; Wilde, Whinnery, Boller, and Noble; and summarizes the Foundation Company's scheme.

II. Published Material

A. Books

Adams, Alton, Electrical Transmission of Water Power, New York: McGraw, 1906.

Beardsley, R.C. Design and Construction of Hydroelectric Plants, New York: McGraw, 1907.

Frizell, Joseph P. Water-Power, 3rd ed., New York: John Wil-y & Sons, 1910.

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Voskuil, Walter H. The Economics of Water Power Development, New York: McGraw-Hill, 1928.

B. Articles

American Manufacturer
"Compensating Works at the Sault Canal," v. 71 (1902) 659-661.

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Schon, H.A.E.C. von. "Theory of Concrete," v. 42 (1899) 135-141 [letter].
Stickney, G.F. "The Compensating Works of the Lake Superior Power Company," v. 54 (1905) 346-370.

Cassier's Magazine
Schön, H. von. "Power from Lake Superior," v. 23 (1902-03) 346-354.

Central Station
Perrine, F.A.C. "Types of Large Water-Power Installations," v. 4 (1904) 361-365.

Electrical World (and Engineer)
"The New Plant of the Union Carbide Company at Sault Ste. Marie, Mich.," v. 32 (1898) 131-133.
"The Opening of the Water Works Power Plant at Sault Ste. Marie, Michigan," v. 40 (1902) 735-736.
"Electrical Development at the 'Soo'," v. 40 (1902) 769-770.
"Electrical Features of the Michigan Lake Superior Power Company's Plant at Sault Ste. Marie, Michigan," v. 40 (1902) 773-774.
Perkins, Frank C. "The Sault Ste. Marie Water Power," v. 40 (1902) 483-485

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"New Water Power plant at Sault Ste. Marie, Mich.," v. 39 (1902) 549-551.

Engineering and Mining Journal
"Completion of the 'Soo' Canal," v. 74 (1902) 310-311.

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"Water Power Development by the Lake Superior Power Co., at St. Mary's Falls, Mich.," v. 40 (1898) 68-71.
"The Water Power Plant of the Michigan-Lake Superior Power Co., at Sault Ste. Marie," v. 48 (1902) 226-229.

Engineering Record
"The 'Soo' Water Power," v. 38 (1898) 161-162.
"Precedents in Hydraulic Power Development," v. 47 (1903) 193-194.
"Inclined Tunnels Buttress Power Plant," v. 75 (1917) 292-296.

Iron Age
"The Jolly-McCormick Turbines at the 'Soo'," v. 70 (November 20, 1902) 1-4.

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"The Turbine Equipment at the 'Soo'," v. 46 (1902) 445-446.

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"Water Power Plant at the 'Soo'," v. 38 (1898) 283-284.

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"Lake Superior to be Regulated," v. 4 (1914) 104-108.
"Proposed Dam of the Michigan Northern Power Co., at Sault Ste. Marie," v. 3 (1914) 178.

Zeitschrift des Vereines deutscher Ingenieure
"Die Elektrizitätswerke Vouvry und Sault Ste. Marie," v. 47 (1903) 917-924.

III. Photographic Material

The Edison Sault Electric Company has a collection of approximately 1000 8" x 10" glass plate negatives. About half of these date from the period 1898-1903. The other half date from around 1907 to 1927.